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THE SPANISH WAR SHIP INFANTA MARIA TERESA.

Length on water line.....	340 ft.
Beam.....	65 ft. 2 in.
Draught on trial, forward.....	20 " 6 "
" " aft.....	22 " 6 "
" " mean.....	21 " 6 "
Displacement on trial.....	6,890 tons.
Immersed area (i. e., wetted surface).....	27,000 sq. ft.

The weight of the vessel (displacement) is made up as follows:

Hull (excluding armor).....	3,630 tons.
Armor (including the belt, 216 ft. long, 5 ft. 6 in. deep, and 12 in. thick).....	943 "
Machinery (including boilers with water supply).....	1,330 "
Coal in bunkers (at 21 ft. 6 in. draught).....	420 "
Armament, ammunition, etc.....	456 "

Stores, etc., bring the total to the designed displacement, 6,890 tons. It may be added here, however, that the vessel has bunker capacity for 1,000 tons of fuel.

The appearance of the vessel ready for trial will be seen from our engraving, for which and the particulars here given we are indebted to *Engineering*. Two 28-centimeter guns form the principal armament. The 14-centimeter Hontoria guns, five on either broadside, with their projecting shield, are prominent features in the view.

Engines:

Diameter of cylinders.....	42 in., 62 in., and 92 in.
Stroke.....	46 in.
Condenser cooling surface.....	14,600 sq. ft.

There are two sets of engines, each driving separate

screws. The above gives the surface of the two condensers.

Boilers:

Four double-ended boilers {	Diam. 15 ft. 3 in.
	Length, 16 ft. 3 in.
Number of tubes in each.....	1,972
Heating surface in each.....	5,067 sq. ft.
Grate area in each.....	169 "

Of the tubes, 280 are stay tubes of $\frac{1}{2}$ in. metal, and 792 plain tubes of No. 8 R. W. G., the external diameter being $2\frac{1}{4}$ in., and the length 6 ft. 3 in. between plates.

Two single-ended boilers {	Diam. 15 ft. 3 in.
	Length, 10 ft. 6 in.
Number of tubes in each.....	526
Heating surface in each.....	2,825 sq. ft.
Grate area in each.....	84.5 "

Of the tubes, which are the same size as those in the double-ended boilers, there are 140 stay and 396 ordinary tubes. The proportion of stay to ordinary tubes is about the same as in the double-ended boilers, 1 to 2.83. These are the boilers for propulsion purposes, the total number of furnaces being 40, each 3 ft. 3 in. in mean diameter, with 6 ft. 6 in. length of firebar.

Total tube surface.....	22,270 sq. ft.
" heating surface.....	25,930 "
" grate area.....	845 "

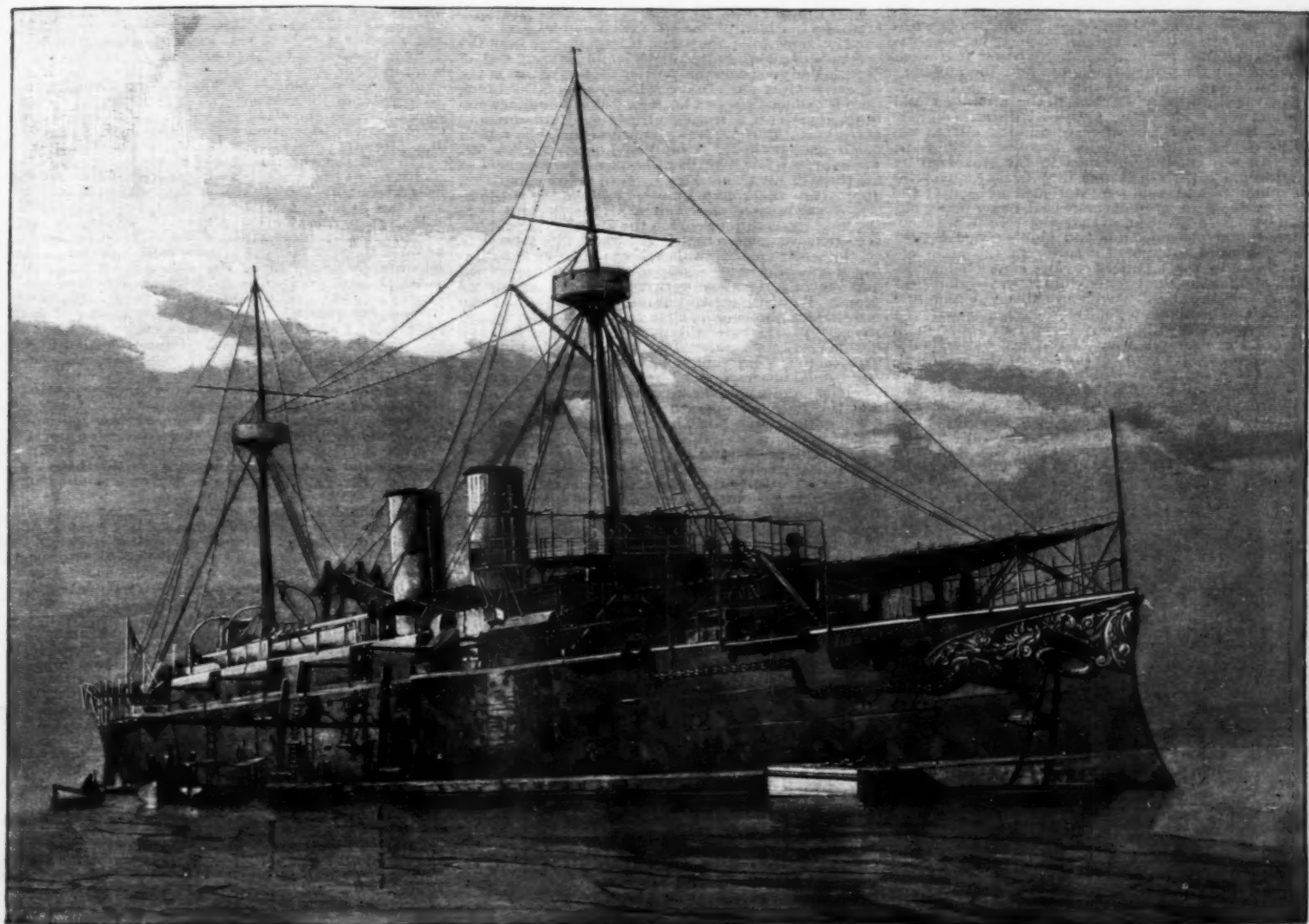
In addition there are two separate boilers for auxiliary machinery—electric light, steering, pumps, etc., boat and ammunition hoists, etc. Each propeller has three blades; the port propeller is left handed, and the starboard propeller right handed; and the blades slew round to enable the pitch to be varied from 19 ft. 3 in. to 22 ft. 3 in. On trial the most successful results were got with a pitch of 30 ft. 6 in.

Diameter.....	16 ft. 5 in.
Pitch, uniform, mean.....	30 " 9 "
Surface of one blade.....	24.24 sq. ft.
" three blades.....	72.72 "

The propellers were used as the log on the official trials. The speed of the ship was guaranteed, instead of the power of the engines, as in the case of British war ships, and the method of arriving at the result was as follows: A measured distance of 1,412 miles at the mouth of Ferrol Harbor was run over four times, twice in each direction, and the mean number of revolutions corresponding to a nautical mile ascertained. The sea trial was then made, and the revolutions divided by the number corresponding to a nautical mile as ascertained. This number, by the way, was 349.5 under forced draught and 347 under natural draught. These are the mean results, and it may be stated that the slip was 15.2 per cent, and 14.5 per cent, under forced and natural draught respectively. This number, again, was checked after each of the trials by the vessel going again four times over the measured distance, as at the beginning. There can, therefore, be no doubt as to the accuracy of the result.

The Spanish government was represented by a large commission, including several eminent naval constructors, and these attended all the trials, and most vigilantly studied the performance of the engines, superintending the taking of diagrams and data, and the measuring of the coal. The results we give are those subsequently prepared by this commission, and it may here be stated that the successful issue of the exacting contract conditions well merited the compliments paid by the commission to Mr. McKechnie, the designer and constructor of the machinery. Included in the naval commission were His Excellency Vice-Admiral Diego Mendez Casariego, president of the commission; His Excellency Commodore Marcial Sanchez; Señor Don Pablo Perez Sesane, superintending engineer, Ferrol Arsenal; Don Leoncio Lacael, assistant engineer, Ferrol Arsenal; Don Davio Bacas, chief engineer of Ministerio de Marina, Madrid; Don Candido Garcia Cantallejo, Don Secundino Armesto, and Captain Miguel de Goitia, the last named three representing the resident inspecting commission of the Astilleros.

The natural draught trials were run on September 18, 1893, the duration of trials being six hours; but prior to this run, and after it, the vessel went four



THE SPANISH ARMORED CRUISER INFANTA MARIA TERESA.

times over the measured distance, for the reason already given. The vessel was, therefore, under full steam on this trial for fully eight hours. The guaranteed speed was 18 knots, and the contract condition was that it must not fall under 17½ knots, otherwise the ship could be rejected. For each complete tenth part of a mile per hour under the guaranteed speed there was a penalty of 80,000 pesetas = 3,000/. But the speed was exceeded by half a nautical mile per hour, having been 18½ knots, notwithstanding a heavy Atlantic swell. The maximum was 18.8 knots, and at no time did the speed fall below 18 knots. The steam pressure was 140 lb., and the mean power, worked out from records taken every 30 minutes, was 9,496 indicated horse power, with the engines averaging 107 revolutions. The starboard engine contributed 4,682 and the port engine 4,867 indicated horse power. There is a remarkable closeness in the power developed in the respective cylinders, and even this closeness in the mean results was excelled in several of the series of diagrams taken during the run.

The forced draught trials were run on October 14, 1893. Six runs were first made on the measured distance, and thereafter two hours' steady running to sea, concluding with four runs again on the measured distance, the total duration of trial being, therefore, 4½ hours. During the whole time the machinery worked exceptionally well. The average speed of 118 revolutions was kept up steadily, the highest revolutions counted being 120. The steam never fell below 140 lb., and maintained nearly throughout a uniform pressure of 145 lb., any excess of which the contract forbade. The mean air pressure in the stokehold was only 1 in. At the beginning of the trial it did not exceed ¾ in., and only in one stokehold was there at any time 1½ in. This was but for a limited period, instructions having been given that it was not to exceed 1 in., although 1½ in. was allowed by contract. The total power developed was 13,722 indicated horse power, of which 6,819 was developed by the starboard, and 6,903 indicated horse power by the port engines. This power was worked out from diagrams taken every 30 minutes during the run. The speed worked out to 20.25 knots, a quarter of a knot over the guarantee. This might have been exceeded, of course, with the full air pressure, but it was deemed advisable to get the contract power without excess. There was no premium, but the conditions of the contract were that for every tenth of a mile per hour below the guaranteed speed of 20 knots, the firm were liable to a penalty of 26,666 pesetas = 1,000/. If the speed had been under 18½ knots, the vessel could have been rejected. As we have indicated, however, the forced draught speed of 20 knots was easily exceeded with a power of 13,722 indicated horse power.

Indicated horse power per square foot grate area:
Natural draught 11.24
Forced 16.24
Indicated horse power (forced draught)
per ton of total weight of machinery... 11.16

The fuel consumption trials were run on October 18 and 19, 1893, the weather being very fine, but with a slight swell on the sea. The vessel was, according to condition of contract, to be run for at least twelve hours with a speed of 10 knots. The coal was to be put in bags to facilitate the calculation of the consumption, which at 10 knots speed might vary, without giving rise to the imposition of fines, between 635 and 680 grammes per hour and horse power indicated, developed by the principal engines and the auxiliary apparatus connected therewith.

The vessel started at 3 o'clock in the afternoon, and six runs were made on the measured distance of 1.412 knots, the cruiser thereafter continuing out to sea until 6 o'clock in the following morning—October 19. The coal was carefully weighed in the stokehold by the arsenal experts, and put into bags, each of 165 kilogrammes, and men were stationed at each of the bunker doors to prevent more coal being taken out than had been weighed, so that the results are accurate. One single-ended and two double-ended boilers were employed to supply the steam to the main engines and to the auxiliary engines connected therewith, and for the auxiliary engines (*i. e.*, steering gear engine, electric light engine, auxiliary circulating pumps, and bilge pumps) one of the single-ended boilers was used, but without any connection to the main engines. The consumption of the coal was carefully recorded for twelve hours in the case of the main boilers, and for eight hours in the case of the auxiliary boiler. The result was that the coal consumption for the propelling machinery was found to be 630 grammes or 1.43 lb. per indicated horse power per hour, the engines meanwhile running at a mean of 55 revolutions and developing 1,331 horse power. From the results of this trial the radius of action of the cruiser was determined according to the bunker capacity, and this was found to be 9,800 nautical miles at 10 knots speed. The details of the engine performance are given in the table, with those of the natural and forced draught speed trials.

One single-ended boiler supplied steam to the following auxiliary engines: Two auxiliary circulating pumps, two fire and bilge pumps, steering gear engine, electric light engine, and auxiliary feed pump, the total horse power developed being 197. The total coal consumed per hour in the single-ended boiler was 230.5 kilogrammes, which gives 1.22 kilogrammes or 2.68 lb. per indicated horse power per hour. The auxiliary engines above referred to are single cylinder engines, with the exception of the electric light engine, which is compound, having cylinders 7½ in. and 13½ in. in diameter by 8 in. stroke.

The contract further stipulated for a trial with one screw, the rudder being thrown over to maintain a straight course, and the guaranteed speed being 12 knots. This trial, under natural draught, was run on October 19. The port engine was used, the rudder being from 12 to 15° over. The mean speed of three runs on the measured mile was 12.56 knots, with the engine running at 85 revolutions. Steam was supplied from one single-ended and two double-ended boilers.

On the same day the starting, stopping and reversing trials were gone through, with the following results: From "full speed ahead" to "stop," 7 seconds; from "full speed astern" to "stop," 6 seconds; from "full speed astern" to "full speed ahead," 7 seconds.

SPANISH CRUISER INFANTA MARIA TERESA. OFFICIAL TRIALS AT FERROL.

	Natural draught, September 18, 1893.	Forced draught, October 14, 1893.	Coal consumption, October 18, 1893.
Revolutions per minute	107	118	55
Indicated horse power, starboard high pressure cylinder	1,332	2,080	259.38
Indicated horse power, starboard intermediate pressure cylinder	1,553	2,290	311.38
Indicated horse power, starboard low pressure cylinder	1,487	2,400	130.14
Indicated horse power, port high pressure cylinder	1,626	2,075	273.65
Indicated horse power, port intermediate pressure cylinder	1,606	2,515	190.00
Indicated horse power, port low pressure cylinder	1,635	2,313	176.65
Total	9,496	13,722	1,271.2
Steam pressure	140	143	110
Vacuum, starboard	11	27½	28½
" port	11	27	28
Receivers, starboard high pressure	117	134	35
Receivers, starboard intermediate pressure	36	52	11½
Receivers, starboard low pressure	7	13	9½ in. vacuum
" port high pressure	112	140	34
" intermediate pressure	36	50	11½
" low pressure	7	15	10 in. vacuum
Mean pressures, starboard high pressure	46.2	54.4	14.7
Mean pressures, starboard intermediate pressure	30.7	27.6	5.5
Mean pressures, starboard low pressure	9.0	13.5	1.42
" port high pressure	47.2	54.5	15.45
" intermediate pressure	21.4	30.4	4.9
Mean pressures, port low pressure	9.9	12.7	2.08
Cut-offs, high pressure	62.5	73	55
" intermediate pressure	70	75	60
" low pressure	70	75	67½
Speed	18.5	20.24	10
Duration of trials	6	4	12

Mean air pressure in stokeholds at forced draught trial = 1 in. of water.
Coal consumption per indicated horse power per hour = 630 grammes = 1.43 lb.

The contract also stipulated for a trial of the engines to ascertain the least number of revolutions required to enable the engines to work with perfect regularity with the valves sufficiently closed, with the normal vacuum in the condenser, and with 145 lb. boiler pressure. This proved to be 13 revolutions, equal to a speed of ship of about 2½ knots. At this speed the engines were kept running for about ten minutes.

The naval commission, after the trials were completed, expressed themselves as being highly delighted with the results of the severe and exhaustive tests to which the machinery had been subjected, and expressed the opinion that no navy in the world had a finer ship, or machinery which had been put to such severe tests, and with such excellent results.

AMERICAN MILITARY ROADS AND BRIDGES.*

By Prof. P. S. MICHIE, U. S. Military Academy.

THE United States, by reason of its fortunate situation, its free institutions, its vast resources, and constantly increasing population, is happily free from the necessity of maintaining a large standing army and of devoting any considerable portion of its revenues to the expensive art of war. In the ordinary acceptance of the term it cannot therefore be regarded as a military nation. It presents a strong contrast to the powerful military states of Europe; for its immediate neighbors, both north and south, are friendly and peaceable people, whose armed forces are as insignificant in numbers as are those of her own. Year by year, as her population approaches the round hundred million, the possibilities of war become more and more remote with even the most powerful nation on the globe. Throughout the extensive domain that acknowledges its sovereignty, the sentiments of loyalty to the existing constitutional government are continually being strengthened and a more perfect homogeneity developed among its people. To all present appearances there seems to be no reasonable apprehension that any question can arise in the near future that will divide her citizens into two hostile parties separated by geographical boundaries. The thorough intermingling, caused by social and commercial interests, aided by the abundant means of intercommunication, the rapid interchange of opinion, and the frequent opportunities for political decision on all national questions, tends to make the political machinery move with the least possible friction.

From this preliminary statement, the truth of which is manifestly self-evident to the most casual observer, it is not surprising that, since the termination of the rebellion, there is little progress to be noted in anything relating to the military profession in this peace-loving country. Prudential considerations, however, have forced the nation to devote its attention of late to the subjects of modern war ships and great guns, in order that its vulnerable coast line may be, in some measure, protected.

With regard to the subject of "Military roads and bridges from an American standpoint," upon which I have been requested to submit a paper, I am at a loss to find anything of interest to say, whether new or old. Strictly speaking, we have never had any military roads in this country, and we owe the purely military bridges that have from time to time been in use in our service to the French and other military nations of Europe. Since the close of the rebellion no modification has had the benefit of experimental service, and the total bridge equipment of the U. S. Army to-day is reduced to a bridge train at West Point, employed to instruct the cadets of the United States Military Academy, and another at Willets Point with the Battalion of Engineers, U. S. Army.

MILITARY ROADS.

From the time of the early settlements on the Atlantic seaboard until the introduction of railways, about the year 1827, the only means of communication between

the outlying settlements and the towns from which they drew their supplies were mere surface roads, which, from time to time, have been improved both in character and in location as the necessity has arisen. The regular army of the United States, which has always been maintained at the least possible minimum strength for the multifarious duties assigned to it, has been constantly kept on the frontier of civilization to protect the ever-advancing pioneer settlements. To preserve its communications, so-called military roads have been established and built by the troops under the direction of army officers. A road was known as a military road when it could be used by wagons hauling supplies for the advanced military posts. In location it was often so directed as to require the minimum labor for its construction, taking advantage of such grades of the natural surface of the ground as would permit the passage of the rough wagons of that day, drawn by oxen, mules or horses. As the country increased in population and prosperity, the traffic over many of these roads became much heavier, so that in parts, at least, they were improved in location and made of a better character by macadamizing. Examples of these earlier types of the military road are that from Detroit, Mich., to the Maumee River, constructed by Bvt. Maj. John Anderson, Topographical Engineers, in 1817; the military road through Mississippi, by Lieut. William M. Graham, Corps of Artillery, 1819-20; those in Florida to St. Augustine, by Lieuts. Lacy and Trenor, 1824, 1825 and 1826, and from the Georgia State line to Smyrna, Fla., by Lieuts. Phillips, Anderson and Clay, Fourth Infantry, 1827-28; in Arkansas to Little Rock, by Lieut. Archer, Third Infantry, 1837; and from Fort Leavenworth, Kan., to Fort Smith, Ark., by Capt. Dimmick and Lieut. Prince, Fourth Infantry, 1837-38.

The United States possessed a vast territory west of the Mississippi River, which was greatly increased by the acquisition of other lands ceded by Mexico after the war. Most of this was an unknown wilderness, which had from time to time been pierced by adventurous explorers from 1800 to 1844, notably by Capt. Lewis and Clarke, 1804, 1805 and 1806; by Maj. Pike in 1805 and 1806, and by Maj. Long in 1819-23; by Capt. Bonneville, 1832-36; Commander Wilkes, U. S. Navy, 1838-42; Lieut. Fremont, 1842; Capt. Boone and Capt. Allen, 1843, and Josiah Gregg in 1844. From 1843 to 1852 many other army officers were detailed to continue these explorations and to locate military roads in the wilderness, and from 1852 to 1857 additional important duties were assigned to them relating to the survey and location of railway routes to the Pacific Ocean. The details of these explorations, surveys, road locations, etc., are given in Lieut. Warren's memoirs of the War Department, March 1, 1858, an epitome of which is published in Vol. I. of Capt. Wheeler's "Surveys West of the One Hundredth Meridian." The whole is a magnificent monument to the thorough training, ability, endurance and devotion of the officers of the U. S. Army and their companions in this most dangerous and difficult branch of their service.

RAILROADS.

It would have been impossible to have conducted the tremendous operations of such a war as that of the rebellion by means of the ordinary wagon roads existing at that time in this country. Railways, which had reached a state of very great development, especially in the North, in 1860, became therefore the true military roads, and require some brief mention in this connection. A reference to Gen. Cullum's biographical register of the graduates of the Military Academy shows that to these officers much of the credit for their location, operation and management is justly due. He says:

"In 1827 the railroad mania began to rage in this country. At that time there were existing only a few insignificant local short roads, aggregating in length less than 20 miles, and there were few educated civil engineers in the United States to conduct larger works. Under these circumstances the government adopted the wise policy of loaning officers of the army, scientifically educated at the Military Academy, to assist railroad companies in carrying out more ambitious projects. In this manner our army engineers became the pioneers in railroad construction and the educators of an able body of civil engineers, who to this day have continued the inherited traditions, methods, discipline, *esprit de corps* and high bearing of their distinguished predecessors."

The general geographical boundary that separated the hostile armies during the earlier stages of the conflict was that indicated by the Potomac, the Ohio and the Missouri Rivers. The main theater of operations of the East, being the triangular portion of Virginia bounded by the Allegheny Mountains, the Potomac River and Chesapeake Bay, was drained by a parallel system of rivers—the Rappahannock, Rapidan, Pamunkey, James and Appomattox—each of which formed an admirable defensive line against an advance southward, for the river crossings were easily destroyed or obstructed. To supply the Army of the Potomac operating against Richmond, reliance could only be placed on the ordinary country roads, which were but fair in good weather, but almost impassable for army wagons and artillery in wet. With roads of such a character the lengths of haul must needs be short from the main supply depots, in order that the large army might be supplied with provisions, forage, ammunition, and the multifarious other less necessary things so requisite for its success. The Confederates depended upon the uninterrupted service of their railway lines that drained the rich granaries of the South to fill their main supply depots, while the Union forces relied on water transportation for the same end. As illustrations of the great difficulties of supply by military roads, it may be well to quote the following statements of two great generals.

Speaking of the Virginia campaign of 1864, Gen. Grant says:†

"During the campaign of forty-three days, from the Rapidan to the James River, the army had to be supplied from an ever-shifting base by wagons, over narrow roads, through a densely wooded country, with a lack of wharves at each new base from which to conven-

* See Cullum's "Biographical Register," Vol. I, p. 163.

† Gen. Grant's Memoirs, Vol. II, p. 572.

ently discharge vessels. Too much credit cannot, therefore, be awarded to the quartermaster and commissary departments for the zeal and efficiency displayed by them. Under the general supervision of the chief quartermaster, Brig.-Gen. R. Ingalls, the trains were made to occupy all the available roads between the army and our water base, and but little difficulty was experienced in protecting them."

Gen. Sherman says:

"To be strong, healthy, and capable of the largest measure of physical effort, the soldier needs about three pounds gross of food per day, and the horse or mule about twenty pounds. . . . Our base of supply in the campaign of 1864-65 was at Nashville, supplied by railways and the Cumberland River, thence by rail to Chattanooga, a 'secondary base,' and thenceforward a single track railroad. The stores came forward daily, but I endeavored to have on hand a full supply for twenty days in advance. These stores were habitually in the wagon trains, distributed to corps, divisions and regiments, in charge of experienced quartermasters and commissaries, and became subject to the orders of the generals commanding these bodies. . . .

"An ordinary army wagon drawn by six mules may be counted on to carry 3,000 pounds net, equal to the food of a full regiment for one day, but, by driving along beef cattle, a commissary may safely count the contents of one wagon as sufficient for two days' food for a regiment of a thousand men; and as a corps should have food on hand for twenty days ready for detachment, it should have three hundred such wagons as a provision train; and for forage, ammunition, clothing and other necessary stores, it was found necessary to have three hundred more wagons, or six hundred wagons in all for a *corps d'armée*. . . . The value of railways is also fully recognized in war, quite as much, if not more so, than in peace. The Atlanta campaign would simply have been impossible without the use of the railroads from Louisville to Nashville—185 miles—from Nashville to Chattanooga—151 miles—and from Chattanooga to Atlanta—137 miles. Every mile of this single track was so delicate that one man could in a minute have broken or moved a rail, but our trains usually carried along the tools and means to repair such a break. . . . Our trains from Nashville forward were operated under military rules, and ran about ten miles an hour in gangs of four trains of ten cars each. Four such groups of trains daily made 160 cars, of ten tons each, carrying 1,600 tons, which exceeded the absolute necessity of the army and allowed for the accidents that were common and inevitable. But, as I have recorded, that single stem of railroad, 473 miles long, supplied an army of 100,000 men and 35,000 animals for the period of 196 days, viz., from May 1 to November 12, 1864. To have delivered regularly that amount of food and forage by ordinary wagons would have required 36,800 wagons of six mules each, allowing each wagon to have hauled two tons twenty miles each day—a simple impossibility in such roads as then existed in that region of country. Therefore I reiterate that the Atlanta campaign was an impossibility without these railroads; and only then because we had the men and means to maintain and defend them, in addition to what were necessary to overcome the enemy."

It is thus evident that railways have become the true military roads of an army, and that their location in the future will have a determining influence on the plans of campaign to be adopted. When armies relied only on wagon roads there was comparative equality in celerity of movement with the successful and the defeated, whereas, hereafter, the greater advantage in this respect will be on the side of the retreating army, provided it can hold the line of railway in its rear. The history of the rebellion scarcely presents a single instance, in such a case, of a successful and, at the same time, of a rapid pursuit. Even in Sherman's Atlanta campaign, with a greatly superior force, the advance was greatly delayed by the frequent necessity of repairs to the railway and bridges, and the urgency for immediate restoration to a working condition led to the organization of an efficient construction corps commanded by specially skilled engineers, of whom Col. W. W. Wright, in Sherman's army, and Col. Herman Haupt, in the Army of the Potomac, were illustrious examples.

CORDUROY ROADS.

The ordinary dirt roads over which the various armies moved during the rebellion were very soon cut up by the heavy traffic to which they were subjected, that even in good, dry weather they were unfit for the purpose of travel by the army wagon; and in wet weather they became absolutely impassable. This was especially the case from the main depots of supply of an army to the several corps, divisions, brigades, or other subdivisions. Fortunately, in nearly all cases, the country was well wooded and furnished abundance of small timber to make a semi-permanent covering for the much-traveled roads. The usual method employed was to lay a sufficient number of stout silt timbers lengthwise, and to place crosswise on these saplings of about four to six inches in diameter, which were tied down by side rails, secured by anchor pickets or other means. Many hundreds of miles of these roads were built during the war for the armies in cantonments, and often it even became necessary to do so for the single passage of an army in advance or retreat. A marked example of this is seen in the advance of Sherman's army over the low, swamp ground between Savannah and Columbia, in his onward movement toward Goldsboro, where, for a time, every foot of road had to be corduroyed. The American volunteer soldier displayed such an adaptability to his surroundings and such ingenuity that he soon acquired a marvelous aptitude for road and bridge building, so as to cause little delay in the army's progress, no matter what difficulties offered themselves to bar its advance.

MILITARY BRIDGES.

Prior to the Mexican war there was no organized bridge train in the United States service, but during that war two complete trains of India-rubber pontoons were constructed and sent to the army in the field. Subsequently these trains were sent to West Point for the instruction in pontoon bridge drill of cadets and engineer troops stationed there. In 1858 they became unserviceable by the deterioration of the vulcanized

rubber of which they were made, and in the fall of that year experiments were undertaken to fix upon a suitable bridge train for the exigencies of the army service. After two years' careful investigation the French wooden pontoon was adopted for the reserve bridge train and the Russian canvas pontoon for the advance bridge train. Owing to the length of the reserve pontoon boat, the wagon required to transport it over the narrow and crooked roads of the country was designed on the principle of the four-horse truck, which, by means of a fifth wheel over the front axle and an inclined wagon bed, permitted the forward wheels to reverse completely under the load and the wagon to turn in a very short space. As an adjunct to these bridge trains, for the bays nearest the shore, the Birago trestle was adopted to form part of the bridge equipage. During the winter of 1861-62 five reserve trains of thirty-four pontoons and eight trestles each were constructed, and several canvas trains were also organized, all of which were thoroughly tested in the war of the rebellion. It was soon found, as the result of experience, that the trestles could be dispensed with in most cases, as the wooden pontoon was sufficiently stiff to be used in shallow depths, or even over marshes and swamps.

Of the numerous examples of the use of pontoon bridges in the rebellion, the following may be cited for illustration:

In the month of February, 1862, a pontoon bridge, composed of sixty boats of the reserve train, was thrown across the Potomac at Harper's Ferry. The river was then a perfect torrent, the water being fifteen feet above the summer level and filled with driftwood and floating ice. The greatest difficulty was experienced in pulling the pontoons into position, and it was necessary to make use of ship anchors and chain cables to hold them in place. Notwithstanding these unfavorable circumstances, the bridge was completed in about eight hours, and the corps of General Banks, with all its trains and artillery, passed over it without accident or delay.

Several of these trains accompanied the army in the peninsular campaign. The pontoons were used in discharging quartermaster and commissary stores at Ship Point; in disembarking General Franklin's command at West Point, and in constructing bridges over Hampton Creek, the streams in front of Yorktown, and the upper Chickahominy. Finally a bridge was built over the lower Chickahominy about 2,000 feet long, over which nearly the whole Army of the Potomac, with its immense trains, artillery and cavalry, passed with promptness and safety.

"During the Fredericksburg campaign it became necessary to force the passage of the Rappahannock. The enemy having entrenched themselves on the bank, prevented for some time the construction of the bridge, until at length troops were embarked in the pontoons and ferried across, where they stormed the rifle pits and held them until the bridge was completed."

"During the year 1863 the pontoon trains accompanied the army in all its marches backward and forward through Virginia, frequently bridging the Potomac, Rapidan, and Rappahannock. In the latter stream the bridges remained in position all winter; and, notwithstanding the frequent floods and quantity of ice formed, but few interruptions occurred upon these thoroughfares. During the campaign of 1864, trains composed of fourteen pontoons and two trestles accompanied each of the three army corps of the Army of the Potomac. These trains attended their corps in the long march from Culpeper to the James River, and, although the roads were frequently very bad, in no instance did they delay the march of the troops or arrive late when a bridge was to be laid. The headquarters train was followed by a canvas train, which, when a crossing was to be made by surprise, was sent forward with the cavalry, who covered the construction of the bridge and held the position till the main body arrived."

In the campaign of 1864, the position of the Army of the James at Bermuda Hundred required much bridge building. The bridge equipage of this army comprised one new reserve train of fifty boats, twelve trestles, with wagons and harness complete; one advance guard train of twenty-five boats, with wagons and harness; and twenty-five canvas and thirty-three surf boats belonging to the Tenth Corps of that army. On the 20th of June the James River was bridged at Deep Bottom, where its width was 575 feet. This was accomplished by silently launching the wooden pontoons a mile and a half above the designated location after dark, and ferrying 1,400 troops across to the point previously selected on the enemy's side of the river, to cover the pontonniers while constructing the bridge. The landing was effected in thirty minutes, and by 11 o'clock the bridge head was defensible against attack.

Another successful passage of the James River occurred on September 29, by the Army of the James, which resulted in the capture of the outer line of the Richmond defenses. In this instance the engineer officer charged with the duty of constructing the bridge had several days' notice of the contemplated movement, so that he was able by personal reconnaissance to select the most suitable point of crossing. The bridge was constructed by successive pontoons at night, in the strictest silence and secrecy, and as it progressed was covered with long manure and hay to deaden all sounds of the necessary labor. The bridge, when completed, was 1,320 feet in length, required six hours for its construction, and was in complete order for the passage of the assaulting column an hour before the time designated for its arrival.

The Appomattox River was bridged at Point of Rocks to connect the armies of the Potomac and James, which, owing to swampy approaches, required a length of 2,625 feet in all; and at Broadway Landing, on August 3, for the passage of the Second Corps to cross Bermuda Hundred to fight the battle of Strawberry Plain on the left bank of the James; and at the same place a canvas bridge, 460 feet long, on August 19, which, not being under the enemy's fire, required only an hour and a quarter for its completion, the abutments having been previously prepared.

The wooden pontoons were found to meet all possible requirements for actual service, especially in the tidal rivers in the eastern theater of the war,

but the canvas pontoon had many defects when it was put to a severer use than that for which it was designed. Its buoyancy was less, and its canvas subject to rot from the manure covering and to leakage from many accidents. While it served its purpose admirably in the Western armies, it could not meet the demands of the heavier traffic in the East.

As an example of the remarkable availability of the wooden pontoon, the passage of the James River by Grant's army in June, 1864, is worth noting. It was highly important that General Lee should be kept in ignorance of the probable movements of the Army of the Potomac after the battle of Cold Harbor, and of the point of crossing the James River. To Lieutenant Michie, Corps of Engineers, United States Army, was intrusted the selection of the bridge site, with the understanding that but twenty-four hours' notice was all that could be given from the beginning of the preparation of the approaches till the arrival of the column for crossing. The site chosen was at Fort Powhatan, where the width of the river was 1,992 feet, and so efficiently was the service performed that approaches on both sides, aggregating over 1,000 feet in length, were corduroyed, and abutment piers on each side of 150 feet in length were built fifteen minutes before the specified time had elapsed. Had it not been for an inexcusable delay of twelve hours in the arrival of the boats, the troops might have marched, without halting, across the river straight on to Petersburg. The bridge, being over 2,000 feet in length, was constructed over a tidal river of great depth, and of necessity the usual methods of anchoring could not be adopted, and the expedient of attaching the anchor lines to a line of schooners moored above and below the bridge was happily devised. Over this bridge the bulk of the troops, trains, artillery, and baggage of the Army of the Potomac was passed without accident or delay, beginning at midnight of June 14 and completed at midnight of the 16th.

The movable column of the Army of the James, in its flanking march to Appomattox, was obliged to move with great celerity. For the repair of roads, bridges, etc., two companies of engineer troops under the command of a field officer marched in advance of the infantry, while the remainder of two battalions followed the leading infantry division. The pontoon train moved with the headquarters train, and in this instance consisted of fifteen canvas boats and four trestles, or in all 380 feet of bridging, requiring for transportation twenty-two pontoon wagons, eight forage wagons, one wagon for spare chests, and one traveling forge. In this march of seven days 20 miles of road and twelve bridges were repaired and built. The weight drawn by the eight mule teams, over poor roads, amounted to 3,168 pounds, which, with the weight of the wagon, 1,278 pounds, made an aggregate of 4,446 pounds to be drawn by each team.

OTHER MILITARY BRIDGES.

The impassability of the ordinary American roads in wet weather often prevents the transportation of the movable bridge equipage, and therefore necessitates other devices for the crossing of streams and rivers. During the rebellion many instances occurred of these improvised bridges, for a full account of which a reference to the admirable volume of Colonel Herman Haupt, on "Military Bridges," will give all the requisite information. Many of the constructions there described are embodied in the "Organization of the Bridge Equipage of the United States Army," adopted for the service in 1869, and published by the War Department in 1870. This system was the result of the studies and investigations of a board of officers, consisting of Generals Duane and Abbot, and Colonel Merrill, of the Engineer Corps, United States Army, each of whom had the advantage of a wide and varied experience in his profession during the war of the rebellion.

THE PASSAGE OF RIVERS BY CAVALRY.

THE importance of cavalry in war, in spite of the strides made of late years by arms of precision, appears likely, if we read the signs of the times correctly, to increase rather than to diminish. The *arme blanche* may possibly not be able to assert its powers on the battlefield itself as in the golden prime of Zieten and Seydlitz, but it will find other opportunities; and the manner in which it can turn them to account will still influence, though less directly so than hitherto, the issue of campaigns. And the gathering masses of horsemen on the western frontiers of Russia, confronted by growing bodies of Austrian and German *reiters*, warn us how the next storm on the Continent will first burst on us. The portents are certainly full of encouragement for the enthusiastic *sabreur*, and it is small wonder that he is throwing himself everywhere into the study of his arm with increased and increasing zeal. Mobility being as the breath of life to cavalry, it is naturally striving to train itself to be equal to every difficulty which may check its activity. It is seeking, not only to be able to brush aside the irritating opposition which comparatively small bodies of well-posted riflemen may throw in its path, but to overcome the natural obstacles which may impede its free and unhampered progress. Horse artillery, and perhaps machine guns, lend it aid for one purpose, and it may fight effectively on foot without sacrificing the dash and rapidity on which it will ultimately rely. A small ditch or rivulet, however, has ere now disordered and paralyzed the splendid intrepidity of a Murat. Therefore much attention is being given abroad to training troop horses to leap such obstacles freely. But an unbridged river may render a well-planned reconnaissance unavailing, if the eager squadrons are to be brought to a standstill by it; and yet, since horses and men can easily learn to swim, such a barrier need never prove quite impassable. Squadrons that are not accustomed to dealing with the difficulties which streams may throw in the way of their unrestricted march are not, in fact, trained as they should be, to be equal to all the exigencies which war may impose upon them. Hence it is that, on the Continent, great attention has of late been given to the passage of rivers by cavalry, and that, especially in Russia, the actual swimming of them has become a very familiar feature of the exercises of regiments and divisions.

Perhaps the memories of the great wars at the com-

* Gen. Sherman's Memoirs, Vol. II., p. 320.

* See United States bridge equipage. Washington: Government Printing Office, 1870.

ment of the century have reminded Russian soldiers of the value of such instruction. During the great invasion of their country by Napoleon almost the whole of a squadron of Polish Lancers was drowned at Kovno. In 1808 a similar disaster overtook the Chasseurs à Cheval of the Guard when they attempted the passage of the Esia on the 29th of December, and on that occasion General Lefebvre nearly lost his life. When, again, the bridge across the Elster was prematurely blown up after the battle of Leipzig, hundreds of French mounted men perished in trying to effect their escape through its waters. The gallant Prince Poniatowski was thus drowned, and Marshal Macdonald only escaped a similar fate by great good fortune. Radetski, one of the most brilliant soldiers of the century, owed his early reputation to the skill and courage he displayed in swimming the Sambre during the early wars of the French republic. Three years later he again swam his horse across the Mineio, and in 1805 he for a third time made himself notorious by swimming a river at the head of a division of hussars, and thus surprising his opponent. The dashing Skobeleff held very advanced ideas as to the capabilities of cavalry in this direction; and, in order to develop the complete powers of the arm, wished to see them undeterred in the presence of obstacles which less carefully trained men might find denying their further progress. It is not, however, to be supposed that he, or any other thoughtful leader, ever entertained visions as to squadrons armed *cap-à-pie* recklessly plunging into rivers, and exhibiting amphibious proclivities totally out of keeping with the received adage as to keeping powder dry. He says: "I do not admit the possibility of men swimming on their horses in full marching order, except over very small streams with firm bottoms, and I consider that swimming, with small rivers, such as the Scoprus (105 feet broad), and going on to regular rivers, such as the Danube, Wisla, Amoor, and Syr Daria, is best carried out by the following three methods." He then proceeds to give an account of some experiments which he had carried out a few days previously with three squadrons of dragoons. Narrow rivers, it seems, might best be crossed if the uniform and equipments of men and horses were ferried over on rafts or small boats, while the men swam their horses across with watering bridles only. The mention of boats or rafts, it will be noted, suggests an element of unreality, for the former are not always at hand, and it takes some time to construct the latter, even when materials are obligingly present, which, it is to be feared, will not always be the case. If such adjuncts cannot be had, it is suggested that a few good swimmers should take a light rope across by means of which an ax or two and a picket rope may be passed to them. A felled tree or stake will then make the picket rope fast on the further shore, and it can be drawn taut from the hither bank. By means of it a detachment, who will carry their clothing, rifles, ammunition, and intrenching tools in a bundle round their necks, may make their way over, and take up a position to cover the crossing of the remainder, who in turn effect the passage after the same fashion. Finally, the horses are swum over in squads. A sub-lieutenant of the Russian Life Guards, it may be added, has designed a bag which, on such occasions, ought to be of immense service. It is made of waterproof canvas, weighs only 2½ lb., and is 4½ ft. long by 2½ ft. broad. This bag will receive the uniform, accouterments, and saddlery of a trooper, and will float buoyantly with them. Thus equipped a man can swim his horse across, and tow his belongings behind him with perfect success. The invention has met with warm recognition in the Russian service, where more than one distinguished officer considers that in independent cavalry operations, during raids into the enemy's territory, and in partisan warfare generally, it may be invaluable. General Gourko, who gained his great reputation by the brilliant raid across the Balkans which he carried through in 1877, goes as far as Skobeleff did in his ideas as to what cavalry may compass, and has recorded a deliberate opinion that rivers and canals need no longer constitute obstacles at which a well-educated cavalry need shy.

It is not in Russia only, however, that much attention has lately been paid to this portion of cavalry training. The French claim that it is they who have led the way here; and they have certainly given much time to such exercises. Their methods are much the same as those which Skobeleff approved of; but they make use of a floating spar to which the horses may be attached in groups; and which, being towed across, much assists their efforts. The importance of accustoming horses to enter the water readily, and not to be frightened at its cold, is justly much insisted on; and constant practice will also make the men become handy, and quick at the work in a marked degree. We read, too, in the *Revue de Cavalerie* of a novel experiment in turning existing materials to account which gave good results, and rendered horsemen independent of any special addition to their present equipment. The camp kettles, which every regiment, squadron or smaller unit carries with it, were attached to stout poles, on which a small raft of great buoyancy was constructed. On this men who could not swim were drawn across; and uniforms, saddlery, arms and accouterments were likewise ferried over with great convenience.

The accounts of both Russian and French experiences finally teach us that, in order to render cavalry perfectly *au fait* in the particular duties we are dealing with, a period of training extending over not less than three months is required. Although less has been published concerning the efforts in the German army, we believe it is no whit behind either of its formidable rivals in studying such matters.

We should be leading our readers astray, however, did we not remind them that, where time is available, the more primitive methods of which we have spoken are not the only ones which the cavalry may adopt. Some knowledge of field engineering and bridging should also form part of a mounted officer's stock of knowledge, and skillful, ready hands may improvise a pathway across a river in a wonderfully short time. The record of some experiments carried out at Limoges last August describes how a regiment of mounted chasseurs, assisted, it is true, by a captain of engineers, threw an improvised bridge across the river there in a few hours. The structure was no less than 56 meters long, and was

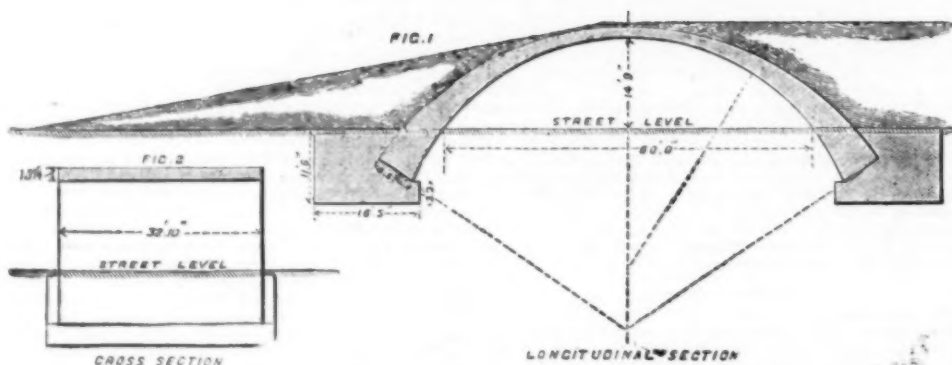
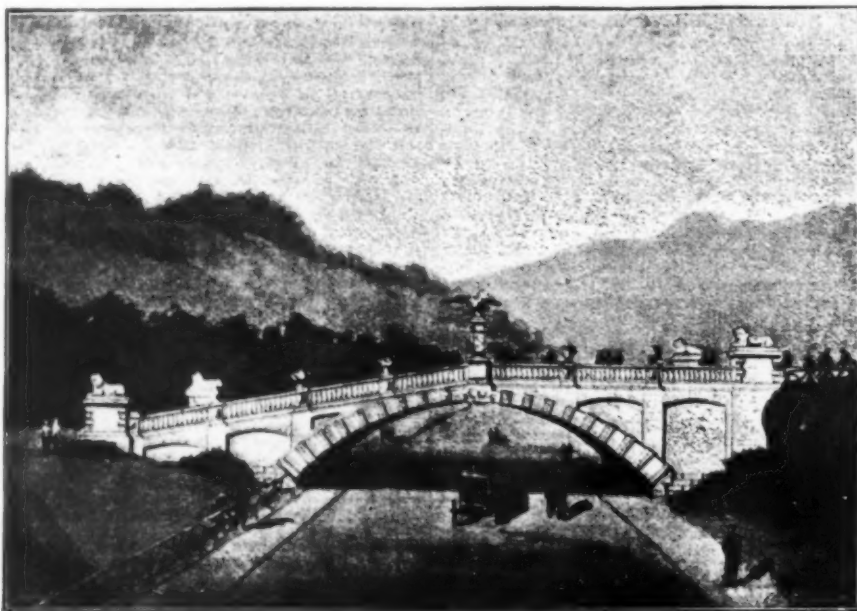
composed completely of such materials as presented themselves on the spot—old telegraph poles, casks, trunks of trees, planks, etc.—and in three hours the work was completely finished and the regiment marched across without the slightest mishap of any kind. Of course the rapidity of the current, the nature of the bottom, the steepness of the banks, and the depth of the stream are all important factors in the problem, without considering which it is impossible to give a decisive opinion as to the merit of the performance. And the reports do not go so closely into these matters as we might wish. Making all due allowances for favorable circumstances, however, enough remains to show how much may often be accomplished, and the value of such a bridge, sufficiently permanent to take many regiments over, is very clear. It is, indeed, to be wished that every regiment could rely on a few officers and men with a complete knowledge and aptitude for field engineering, and should be able to undertake duties at a pinch with the same readiness that is expected in most armies from engineers or artillery alone. Courses of instruction, no doubt, are annually held already, and the importance of this side of a trooper's education is not, therefore, altogether overlooked. But we fear that those who have been instructed are not required to put their knowledge to practical application as often as might be wished, and that the passage of obstacles scarcely forms so large a

CONCRETE BRIDGE AT THE ANTWERP EXHIBITION.

THE use of concrete as a substitute for masonry has made a good deal of progress during the last few years. Thirty years ago it was almost confined to foundations, engineers who used it for retaining walls were thought venturesome, and there were few who considered it a suitable material for the construction of arches.

Though concrete bridges are now no longer a novelty, there seems to be great difference of opinion as to the most suitable proportions of cement, sand and stone, in fact, it cannot be said that there is any rule in the matter, beyond the "rule of thumb;" we can only be guided by the experience of others. But as it seems evident that concrete will be employed for arches of much greater span than any which have yet been made, while none can assert that we have reached the point below which it would be impossible to reduce the proportion of cement, it will be interesting to take note of what has already been done with this material, and a description of one of the most recently constructed concrete bridges will serve as an example of present practice in Belgium. It will be seen that the method of mixing differs somewhat from that usually adopted in England.

The North's Portland Cement Works Co., Antwerp,



CONCRETE BRIDGE, ANTWERP EXHIBITION.

portion of the ordinary routine of a drill season as is desirable. It is a noticeable fact that Napoleon recognized the immense assistance which mounted engineers might be to an army, and Frederick the Great, in his desire to develop the efficiency of his squadrons, turned his thoughts in the same direction. He would like, he tells us, to give the advanced guard mounted sappers to break up the enemy's road, cut down small woods, make a small bridge, mark a ford, prepare positions for defense, or cut down or scarp the banks of a rivulet. General Brialmont, a high modern authority, would attach a company of mounted sappers to each division of cavalry for duties such as Frederick had in view, and quotes the experience of the American war of secession to fortify his arguments. In these days, when railways will play so important a part in military operations, work of destruction, if not of construction, may often have far-reaching results, and the opportunities of a leader of cavalry, raiding far ahead of the force behind him, are immense. With an army such as ours every man is needed for his own particular place, and we can afford few specialists. What an engineer can do a cavalry soldier can, within certain limits, also undertake, and there seems no reason why regiments should depend on adventitious aid to perform duties which they might easily enough with a little special education be equal to themselves. Nor need the dash and rapidity which must always remain the main characteristic of horsemen be sacrificed. To be ready for all emergencies is surely no unworthy ambition for even the smartest and most enthusiastic sabreur.—Saturday Review.

has put up a handsome concrete bridge in the grounds of the exhibition. It serves to cross the Rue des Sculptures, which had to be left open for traffic, and it leads from the garden in front of the Industrial Hall to the Congo section, which is situated between the Machinery Hall and the picture galleries. Fig. 1 is a longitudinal section of bridge, and Fig. 2 a cross section. It will be seen from these that the arch is 6 ft. 6½ in. thick at the springing, and only 1 ft. 7¾ in. at the crown. At the street level it is 4 ft. thick. The height of the under side of the arch above the roadway is 14 ft. 9 in., and the inside width at this level 60 ft. The width of the bridge is 32 ft. 10 in., and the total length 131 ft. 3 in.

The ground at the abutments was excavated to a depth of 11 ft., and in doing this a wall about 3 ft thick was discovered, crossing the line of the bridge obliquely. This wall was demolished to within 3 ft. above the seat of the foundation, and the rest of the ground was found to be tolerably firm sand, slightly argillaceous. The abutments are 16 ft. 5 in. wide, and the concrete was rammed down in successive horizontal layers, each 6 in. thick.

The mixture for the concrete in the abutments was not the same as in that for the arch; but in both cases a mortar was first made, and subsequently mixed with the stone. For the abutments, this mortar consisted of one of cement to four of sand, while for the arch one of cement to two of sand was used. In each case 10 per cent. of water was added, to work the materials up into a rather dry mortar. Forty-five parts of this mortar were then mixed with a hundred parts of

crushed porphyry. It will thus be seen that in the abutment there is only one part of cement to fifteen of sand and stone, while for the arches the proportion is 1 to 8½. For the centering five wooden trusses were used, placed 6 ft. 7 in. apart, and covered with ½ in. planks. The construction of the arch was commenced on December 18, 1893, and was finished on the 23d of the same month. A week later a severe frost set in, the thermometer falling to 10 deg. Centigrade below zero—14 deg. Fah. On January 23d the centering was removed, and though careful observations were made, no settlement could be detected. To avoid the infiltration of rain, the extrados of the arch and the tops of the abutments have been coated with a mortar consisting of equal parts of cement and sand. The general appearance of the bridge is very satisfactory.—*The Engineer.*

A TEMPORARY TRESTLE.

By ROBERT A. CUMMINGS, Assoc. M. Am. Soc. C.E.

IN railroad work, where the temporary trestle is usually a makeshift, and the material employed is the old lumber taken from permanent trestles, the design is usually left to the judgment of the practical bridge carpenter. There are yet many railroad standards of trestles in use, in which the defects in details seriously affect the general design; and it is only by a comprehensive and practical knowledge of the construction, requirements and maintenance of permanent trestlework that a satisfactory design can be made for temporary trestlework.

In the design of temporary trestlework, the employment of disputed parts of the permanent structure, such as corbels, long ties, etc., should be avoided. Proper provision should be made for the lateral realignment of the track, the elimination of surplus refinement in details of ironwork and woodwork, and only the employment of the necessary parts to thoroughly secure the structure for quick erection are requisites for success.

For temporary trestlework or scaffolding the author has abandoned the use of mortises, tenons and pegs, as requiring too much labor and time in the erection. He has quite successfully employed for some time "dogs" or "dog irons" to fasten the caps and sills to the plumb and batter posts.

Referring to the illustrations, Fig. 1 is a front view

lumber was nearly as good as new after nine months' use.—*Railroad Gazette.*

ENGINEERING A LEARNED PROFESSION.*

By R. H. THURSTON, Director of Sibley College, Cornell University.

IN the early springtime of the world, when quickened intelligence was budding into semi-civilization and the Greeks were naming their gods and their demigods, Zeus, Jupiter the Supreme, was believed to have found his greatest, most powerful and most productive coadjutors among the creators of mechanisms and of machinery for war and for peace. As Bacon says: "Inventors and authors of new arts and such as endowed man with new commodities and accessions were ever consecrated among the greater and entire gods." These, the progenitors of the modern "engineer," were, in those halcyon days, among the heights of Olympus and on the plains of Hellas honored as the wisest, the greatest, the most helpful and beneficent of all the Olympians. Such beings to-day are not classed among the immortals even of earth; but their work stands imperishable as safely and as certainly as then.

When the Greek built into Egyptian civilization the Alexandrian university, and this, its noblest production, rose before all coming times, an example and a challenge, the work of the man of science, of the mechanic and the engineer, still honored little less than the wonder-working gods, became forever visible, permanently beneficent, grandly recognized, and it was Ptolemy Philadelphus, with his alembics and crucibles, Hipparchus telling off the catalogue of the stars, Eratosthenes measuring the size of the world, Archimedes constructing the laws of mechanics, Euclid creating geometry, Hero inventing the steam engine, the chemist, the astronomer, the engineer, who rose highest toward Olympus, in the view of both contemporary and later peoples. Yet to-day, as the ordinary mortal, accustomed to the light of sun and of moon, walks through his insignificant and fruitless life, indifferent to his presence and their glories; so the peoples of the whole civilized world, finding the mechanic, the inventor, the engineer, mortals like themselves, and taking their world-building as a matter of ordinary course in everyday life, now rarely appreciate these immortals or the blessings coming of the skill

iteet and military engineer, and foremost among the great mechanics of his time. His inventions of military engines, his great public works in the duchy of Milan; his construction of the science of hydraulics, his invention of the saw and of breech-loading ordnance, and his anticipation of the steam gun and of the steam engine were his most useful contributions to the arts of his time, and constitute the highest of his many claims to fame and grateful remembrance.

Michael Angelo, like every great artist, owed his success in large part to his natural talent as a mechanic; and his genius as an engineer displayed itself when, during the siege of Florence, he was given charge of the construction of the fortifications.

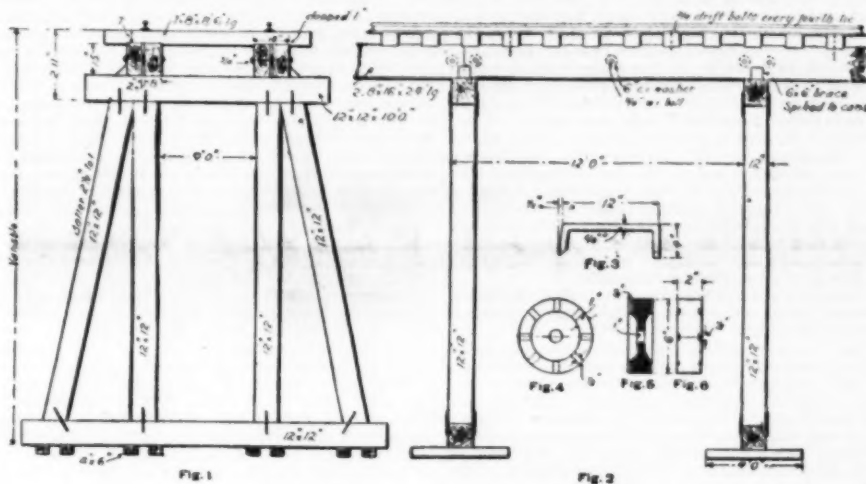
The intuitions and the manual skill of the mechanic are as essential to the artist as to the physicist engaged in research; the scientific bent is as essential to the engineer also as is constructive ability. Every great mechanic and inventor, all distinguished engineers, have combined both, and have illustrated the scientific method in their work, and most successfully and thoroughly in their most famous achievements. The history of the inventions which gave us the modern steam engine illustrates this point admirably. James Watt found the engine of Newcomen wasting, as he says, three-fourths of the steam which entered it. He sought the causes of these wastes, discovered them through a systematic and thoroughly scientific process of research, contrived the remedies by a similarly scientific study of methods, and the modern steam engine was the outcome of his investigations. Discovering, as a result of experiment, that the source of loss was mainly the alternate heating and cooling of the cylinder, and measuring its amount, he found that this loss accounted very largely for the wastefulness of the engine. So systematically did he proceed with this investigation, that his experiments revealed to him the then new fact of the existence of the latent heat of steam, as it came to be called, and its amount; and James Watt shares with Dr. Black the honor of independent discovery of this important physical phenomenon. Scientific methods of ascertaining scientific facts were the basis of all the important work of Watt, as of nearly all later great inventors. These are the methods of the century.

Fulton, although a talented inventor, is not the inventor of the steamboat, as he is so generally considered. That great modern invention is the product of many minds; but Fulton was the first to systematically study the problem and to apply scientific methods to the production of what he saw with precision was the size and kind of steam-propelled vessel demanded at the time. After years of study and of experiment, determining by the best methods then available the resistances of different forms of bodies moving in fluids at various speeds, and after building experimental boats, he ordered from Boulton & Watt precisely the engine required, bought of Charles Brown, a New York builder, just such a hull as he needed, and thus by their combination produced the steamboat in practically satisfactory proportions, and made it a commercial success.

George Stephenson was not the only or the first inventor of the locomotive; but it was his scientific mind, his systematic methods, that made it, for the first time, a successful machine, and, sixty years ago and more, so far perfected it that the locomotive of to-day is the refinement simply of the Planet, of George Stephenson, built in 1825.

The telegraph, the telephone, all modern machinery; all our immense systems of public works; our bridges and our buildings; our marvelous manufacturing systems; all that makes modern life and civilization, is the outcome of those scientific discoveries and of those scientifically developed inventions which have come of the new learning and the new ways of the contemporary mechanic, inventor, and engineer. It is coming to be the fact, and rapidly, that the mechanic is learned in all the history, all the wisdom, all the methods of his craft; the inventor is coming to rely upon knowledge rather than inspiration for the attainment of now usually well-defined purposes; the engineer has come to be a cyclopedia of knowledge of the state of his art, familiar with all expedients, with every scientific fact and principle required for the prosecution of any great work. In fact, invention is now largely superseded by deliberate designing on the part of the engineer; and the specification of a requirement leads promptly to the preliminary investigation of ways and means, and presently to their application in the production of precisely that machine or that combination of machinery which will most readily and economically effect the specified result.

The conversion of the vocation of the constructor into the profession, the learned profession, of engineering, has been formally in progress a comparatively short space of time. Archimedes, of Syracuse, was a man of learning; he would be regarded, judged by our standards, as an amateur engineer. Watt was a great engineer; he would be regarded ordinarily as an amateur in science. The ideal engineer of our day is a learned man of science, having the application of natural forces and laws to the advantage of the race as his vocation. His has come to be a learned profession in a more precise sense than any other, with the possible exception of that of medicine in its surgical branch. He is expected to be familiar with all those sciences, physical, mathematical, philosophical, which contribute to give him control of those forces, and to enable him to make them available for every purpose, in the arts either of construction or of production. The unlearned mechanic of the earlier generations, and the man of science of his time, were separated by an enormous gulf; but their union constitutes the essential prerequisite to truly successful engineering. It is this union which has been effected most completely in our time, and which unquestionably has been one of the grandest accomplishments of modern statecraft. The inventor of the eighteenth century has become the systematic designer of the nineteenth as a natural consequence, and the vocation of the typical Yankee of the jack-knife is nearly gone. Newcomen invented the modern steam engine, and Watt was its improver and the author of nearly every later refinement. The one effected perhaps the grandest of all modern inventions by a stroke of genius in application of the wonderful intuitions of the unlearned mechanic; the other attained a well



A TEMPORARY TRESTLE.

of a temporary trestle showing the use of "dog irons." Fig. 2 is a side view of the same. Fig. 3 is a detail of "dog iron." Figs. 4, 5 and 6 are detail views of a cast iron packing block.

The dog irons (Fig. 3) were made of ½ in. square wrought iron, with chisel shaped points at right angles to each other. This was done in order to prevent the splitting of the timber when driven in, by cutting the grain of the caps and sills at right angles to its direction. One leg of the dog iron was flared out ½ in. more than a right angle in order that the timbers would be close together when driven in. Two of the dog irons are driven at the same time, one on each side, the simultaneous driving preventing the post from changing its position. The batter posts are slightly dapped into the sills to increase the friction, and are additionally secured by one dog iron on each side. Where it was considered necessary three or four dog irons were used.

The stringers break joints and simply rest on the caps, being held in position by triangular pieces of wood spiked on each side to the cap. This method of construction is of great advantage in the slight realignment of track.

The tops of stringers are firmly held in position and well braced laterally by the ties, which latter are dapped an inch on the stringers. On curves every fourth tie is fastened by ½ in. drift bolts to the stringers. The rails are then directly spiked to the ties with the ordinary but "deadly" track spike. The ties were the ordinary sawed track ties.

In Figs. 4, 5 and 6 is shown a front elevation, section, and end elevation of the cast iron packing block employed, the radial grooves being provided for drainage of water that would otherwise remain between the wood and iron or in the hollow center. These packing blocks are very easily placed in position, are cheap and durable, but, above all, do not induce rot; on the contrary, have a tendency to preserve the wood, through the oxidation of the iron.

While in charge of recent railroad construction, the author employed for overhead and undergrade crossings, etc., a similar temporary trestle, where the size and quality of lumber used corresponded to that employed on the main line permanent trestles. By this means the cost of the temporary work was reduced to the labor of erection. By careful handling during the erection and the taking down of the structure, the

of the mechanic, of the ingenuity of the inventor, or from the sciences finding application through the learning and the wisdom of the engineer. But in the last hundred years these men have converted a material barbarism into civilization, given the world comfort and wealth, rescued the intellectual life of the peoples from the dangers coming of poverty and overwork, and have made over the whole social system. The labors of the deified Greeks were but the first, slowest, smallest and weakest steps in a progress which the modern successors of those gods and demigods have converted into a mighty and irresistible and never-to-be-checked acceleration. Newton has far outstripped Euclid; Lavoisier has vastly excelled Ptolemy; Gilbert founded a physical science such as Aristotle never imagined; Watt accomplished infinitely more than did Hero; and the inventors of the power-loom, of the locomotive and the steamship, the builders of the railway, the makers of the telegraph and the telephone, the contrivers of the modern printing-press; each and all have earned even if they have not received nobler honor, a more generous appreciation than did any one of the Alexandrians.

The work of the engineer, of the mechanic and of the inventor stands everywhere as among the highest, the most useful, the most godlike, intellectual products of the human brain; but it is not so universally admitted that the mechanic is worthy of honor, much less of immortal fame; that the inventor deserves recognition, both sentimentally and in material things, as our greatest mortal benefactor, or that engineering stands to-day as it has always properly stood, a learned profession; exemplifying its learning by its works, and demanding more of the neophyte and more of the practitioner than probably either of the recognized contemporary professions. Even in the "dark ages" the engineer and mechanic, a rarer character then than now, occupied a higher position and was accorded more respect and greater honors than to-day; and Gilbert, the horologist, as Pope Sylvester II., by his accomplishments as a mechanic added luster to his fame as a sovereign. Albertus Magnus is remembered less as a theologian than as a master of the arts and sciences of his day.

Leonardo da Vinci, poet, painter, sculptor, was arch-

* An address delivered on the occasion of the laying of the corner stone of the engineering building of the University of Illinois, December 13, 1890, at Champaign, Ill.

understood and clearly seen purpose by the exercise of logical reasoning based upon facts and data revealed by precise and thoroughly scientific investigations. The one illustrates the old, the other the new spirit and method. The ways of the engineer of our time are those of the deliberate systematic and necessarily successful designer; that is to say, he is an inventor by virtue of his science. His method is first to exactly define his object, then to apply all the resources of modern science to its complete and accurate accomplishment. Invention, in this scientific sense, can today be taught; and the distinguished professor of engineering who advertised in his college "catalogue" "systematic invention in machine design taught," was absolutely right, and his critics were as absolutely wrong; and his idea is illustrated by the daily and usual practice of every manufacturing establishment in the land constructing machinery, of whatever kind. The records of our Patent Office are to-day proof that invention and patented devices are the outcome mainly of the systematic labors of the workers, in their own restricted fields of specialization, of the designers, and are not the haphazard product of untalented genius. The production of inventions has come to be a vocation with the mechanics and engineers of our day, and they are educated and trained to that pursuit. When a man like Edison now makes this his principal business, he surrounds himself with scientific assistants, as with so much machinery of production. The union of the mechanic and the man of science, and the fruit of that union, the engineer, so rarely seen in the older times, has come to be as common as the practitioner of medicine and surgery, who, more than any other man, the engineer perhaps excepted, unites the practice with the theory of his vocation, combining most perfectly science and art. The engineer is to-day the exponent of all the arts of the mechanic and of the sciences of all the physicists.

But while it is true that the profession of the engineer, from the time of the ancients, has been a learned profession, its membership was then always greatly restricted, and was mainly composed of great military engineers, educated in the learning of the time as the sons of aristocratic families, and directed in the application of their knowledge of the laws of nature, by strategical situations, and, as a rule, working purely for the purposes of war; to which the arts of peace were, in those rude ages, considered principally tributary. It is only in our own time that schools of engineering, having for their purpose the training of men for this profession, have been formally or often established. Medicine and law and theology have had their schools from the times of the Sclerian University, A.D. 850; but the germ of the engineering school only appeared with the foundation of the Ecole Polytechnique, in Paris, by the action of the National Assembly, a century ago (1794). Since then, and especially since the Continental governments took up the education of their peoples, deliberately, as duty of highest statecraft, progress has been comparatively rapid. Every nation now has, or is coming to have, a system of technical education; and this is, in all countries, the essential and fundamental basis of the professional school of engineering; with which, indeed, it is often confounded. A technical system, comprehending the manual training and the trade school, as well as the professional schools of the engineer, is now organized and sustained as a principal public policy by every nation controlled by statesmen, or anywise influenced by considerations of national welfare. When Newton and Milton called for the establishment of such an education of the people as the Marquis of Worcester declared to be the foundation, for modern times of all national prosperity and permanence; when Vaucanson contributed his collections to the germ of the Conservatoire des Arts et Metiers; when Descartes urged the institution of lectures on the arts and the physical sciences for the instruction of the working people; these great minds were preparing the world for the commencement of the grand work which is still in its very incipency. We call it the "New Education;" but it is simply the rounding out and symmetrizing of the old, and its adaptation to the needs of a later community of peoples.

The evolution of our educational systems has been influenced, often controlled, by political, theological, and social conditions and movements which have checked its natural growth and development, and which, while stimulating its progress in some directions, have checked and stunted its growth in others. The Alexandrian school was a real university, giving instruction in all the arts, all the literatures, and all the sciences, as well, of its day. The sciences were, in fact, the most prominent and highly developed of all its courses, and then, as now, it was seen that they were to be the foundation of the material life of the nation; that they were the basis of all the arts. But the monastic elements of medieval life, and the unsettled character of all social conditions in the later centuries, diverted attention almost exclusively to the literary and philosophical side of the old and broad curriculum, and the university and the schools became dissociated; the scientific and industrial side was lost, and education entirely ceased to have place in the life of the people, or purpose and result in the promotion of their interests. All through the middle ages, the schools were cloistered; and pedantry, rather than learning, characterized the scholarship of those centuries. It was only when the modern system of so-called technical education began to take form that the interests of the people and of the whole nation became a factor influencing the cultivation of the popular mind. The revival of the physical sciences, in the seventeenth and eighteenth centuries, dating from the work of Gilbert, of Lavoisier, and of their contemporaries, led by an easy road to the institution of the new education and the broadening once more of the curriculum into its ancient proportions and symmetry.

Universal education is university education, necessarily; and the education of an entire people presupposes and compels the establishment of the true university with its complete pantology, and its specializations in every branch of thought, industry, and professional work, as absolutely as it requires the organization of a public school system of primary and secondary instruction. This reinstitution of the true university, comprehending all the literatures, all the arts, all the sciences, of the time, is the characteristic movement of the nineteenth century; and it now has its highest and best expression in the United States, and

especially in those states which have regularly chartered state universities as the crowning element of their whole educational structure.

It is this fact and these considerations which make this occasion one of special interest. We here inaugurate an essential part of the university system, as we are now beginning to recognize it, in the state university—in the culminating division of the educational system of a great state. We here institute one of those modern aids in the erection of the vocation of engineering to the status of a learned profession which have come to be, in the United States, as nowhere else, the most advanced, and often the most fruitful, of all branches of technical instruction. It is in the United States, and in institutions like this, that this latest and strongest of the learned professions has taken most complete and perfect form; and where the courses of professional training have come to be most thoroughly adapted to their special purpose. In our country, and in our time, schools of engineering are coming to be planned with direct reference to the requirements of the profession, and to embody instruction in their curricula precisely adapted and arranged with a view to giving the fundamental theory of the scientific side of the profession with something of practice, while in the stronger schools even a considerable amount of research is carried on by the more advanced students. This marks the highest development of the professional school. When it provides not only instruction in the special learning of its field, but through research even adds to the sum of human knowledge, within its own department, the school of engineering earns our greatest respect and does its noblest work.

Although the establishment of technical education in the United States was primarily through the organization of our earlier schools of engineering, the most effective work was done later, when, in deference to an awakened and exceedingly active public spirit, calling for systematic technical instruction in this country, such as had for a long time been in operation in Europe, the "Morrill Act," the "Land Grant Bill," of 1862, was passed by Congress. The movement was an illustration of the fact asserted by Richter: "The spirit of the nation and of the age decides, and is at once the schoolmaster and the school; for it seizes on the pupil to form him with vigorous hands and powers."

As I have elsewhere remarked: "It is the spirit of our age which is being felt in this modern movement toward an education of the peoples. It is that which would educate a man for his life and would train him for his work. It would give him the knowledge and the intellectual capacity needed to enable him to profit by the opportunities coming to him in his intellectual life; while, at the same time, it would prepare him to secure those opportunities and to care for family and self, through the exercise of his faculties, in some definite and profitable department of human activity." And this spirit of the age, establishing the new education, has in this country, as abroad, been a most generous spirit. It has recognized the fact so tersely stated by Wendell Phillips: "Education is the only interest worthy the deep, controlling anxiety of the thoughtful man." Our republic is not likely to be like "the fair fabric of justice raised by Numa," which, as Plutarch says, "passed rapidly away, because it was not founded on education."

Our country is to-day spending annually \$140,000,000 upon public school education alone—nearly as much as all the Continental nations together. While, according to Carnegie's collated figures, those countries spend five times as much upon armaments as upon schools and colleges, the United States gives nearly twice as much to education as to war. Europe burdens her people with the overwhelming costs of standing armies and mighty navies, and does comparatively little to give them either the physical comforts or the intellectual advantages of best contemporary life. America spends her surplus in rewarding patriotism and in founding schools and colleges, and in giving the nation that higher life which is the birthright of every human creature. She supports an army of over 400,000 teachers, leading thirteen millions of children into that higher life. And yet, after all, the expenditure is but about \$25 per capita of pupils, \$2 per capita of population, in even the most liberal States. Judged by European standards, we are more than liberal in our support of education; but, judged by the relative proportion of taxes diverted to this purpose, the United States, the most enlightened and the most generous of nations in providing for the coming generations their most essential need, intellectual food, still does little for this grandest of her tasks. When our whole enormous pension list shall have been cleared, through the operation of natural causes, the appropriation of this tremendous annual outgo to the cause of education, could it be brought about, would be no more than a fair tribute to the best interests of the people.

Strange to say, while we have 13,000,000 of children in our public schools, and even this immense number representing only about one-half the inhabitants of minor age, there are in the United States less than 200,000 students in our colleges; only about one family in a hundred has "a boy in college." It is collegiate and higher technical education that requires most attention with us, and technical most of all; for the schools of engineering only graduate annually, to-day, about 800 students, and have probably an attendance not exceeding about 4,000. The schools of science outside this branch only instruct about an equal number. There should be 10,000 students in such colleges and professional schools as these, and 15,000 in the technical high schools, of which we have so very few, where Europe has hundreds; while there should be, to make our country as rich in opportunity as the Continental nations, schools of manual training and trade schools, giving the kind of instruction most needed by the children of the average citizen to a million of our boys and girls.*

We need, and vastly more seriously than our people realize, a grand system of primary schools, precisely adapted to the immediate requirements of the people and their children; this is gradually coming into shape with the progressive adaptation of the great common school system of the country to the demands of these later times. We need, and in no less degree, trade schools, and so-called manual training schools,

throughout our country, and especially in the great cities; and this demand is being met, sporadically and unsymmetrically, but splendidly, nevertheless, by private munificence, such as is illustrated by the work of Cooper, of Pratt, of Drexel, and of Armour and others. We need, just as vitally and as the final and completing element of this, which should be a universal and uniformly distributed system of education, the complete university, with its humanities beside its technical schools; offering its students opportunities of study in the whole universal cyclopedia of the literatures, the sciences, and the arts of our time. We should have to-day, and lacking it to-day, should provide at the earliest possible moment, as Jefferson said, "A system of general instruction, which shall reach every description of citizen, from the richest to the poorest;" and of which he said, "As it was the earliest, so shall it be the latest, of all the public concerns in which I shall permit myself to take an interest." This last of these needed parts of the grand whole is now, late, but better than later, coming into view as the contemporary "State University."

The State University is that one among our peculiar institutions which is at once most characteristic of the American spirit and most effective in the promulgation, perpetuation and stimulation of that spirit. As Bryce says in his magnificent work on "The American Commonwealth": "They are supplying exactly those things which European critics have found lacking hitherto to America; and they are contributing to her political, as well as to her contemplative, life elements of inestimable worth." And fortunately for us, as the same author remarks, "While the German universities are popular, but not free; while the English universities are free, but not popular; the American universities have been both free and popular;" and they are becoming more and more popular constantly as they find more and more fully right ways of promoting the best and highest interests of the people, through extensions of the newer side of education. Their usefulness is, in a manner, gauged by their capital; and the fact that their property amounts to more than \$100,000,000, of which about one-half is in the form of productive investments, the other half in buildings and equipments, is one of the most encouraging features of the progress of the day.

But a look into the future leads to very cautious gratulation; for these endowments, great as they are in the aggregate, and vast as is their value to the nation, seem likely to prove, ere many years, totally inadequate to their work—not simply because the need grows more rapidly in every direction than does the fund which supplies it, but, and especially, because the value of invested capital is steadily and somewhat rapidly decreasing, and the income from the best and safest investments—those in which only such funds should be placed—once seven and eight per cent., recently six per cent., is already fallen to five per cent., and in many cases to four, and bids fair to continue to decline until it passes below even the figure marking to-day the returns upon the securities of those most powerful of commercial nations—Great Britain and the United States.

This means that a fixed capital can, after a few years, support but a fraction of the good work that it could, and perhaps did, sustain a few years back. Endowments have to-day but two-thirds the value, gauged by their returns, that they had a generation ago. A generation hence they will have half that value, or very probably, should progress continue in the twentieth century at the same rate of acceleration that we have seen in the nineteenth, they may have less than one-fourth their former maximum value. This simply means that endowments, ere long, will cease to be reliable support for great enterprises of a public nature, like the higher education of the people. It means that we must look to our legislatures to find ways and means of sustaining this highest work of the statesman and the citizen. Most happily, this great economic change, and its possible fatal effect upon endowed education, has already attracted attention, and our legislators have long since commenced the replacement of endowments by the more reliable and permanently effective system of state support; making the universities in a large majority of the states public institutions, sustained and continually promoted in growth and in character of work by the contributions of the people.

Three-fourths of the states of the American Union already have universities, more or less completely independent of endowments, and supported as state institutions. The "Land Grant Bill" of 1862, which we owe to Senator Morrill and his able colleagues of the days of our civil war, appropriated 30,000 acres of public lands to each state, for each one of its senators and representatives in Congress. It was this act which gave the most effective impetus to the great enterprise of providing higher education, of a "liberal and practical" sort, for "the industrial classes." This one statesmanlike act has placed \$16,000,000 at the service of higher education, and distributed it among all the states. Properly administered, this munificent gift would have provided nearly a hundred and sixty million of dollars, instead of sixteen, but it was rich in its results, notwithstanding the wastes and mistakes which attended its application. Following the example of the general government, the states have made, in many cases, as here, noble contributions to the same cause, often supplementing the gift of the United States by far more liberal contributions from the treasury of the state. In fact, the states had, in some instances, adopted this wise policy, long before the appropriation of government lands to the purpose was proposed by the statesmen of 1862. Beginning with the formation of the "Northwest Territory," in 1787—where, as its first duty, a township set apart in organization a section of its public lands for such purposes—states and territories alike, in all this western country, have ever since given liberally to education. About 150,000,000 of acres of public lands have been given, to date, to this greatest of public purposes. This is the nationalization of education, and this is the first instance in history of the provision, by any people, of such a complete and well-adapted system of promotion of its own best interests. To-day, about \$150,000,000 are appropriated, annually, by our people, to the support of public education, of all grades.

*Sibley College Reports.

*Bryce; II, 560.

This policy is the essential element of permanent advance. As I have elsewhere said, in discussing this subject:*

"That essential element of permanent and highest success—regular, ample and certain income—can only be insured by the state and through a fixed and positive system of legal appropriation. Every great and famous university in Europe stands upon such a basis of state aid; every college and university in the United States, having no such backing, is in constant difficulty from the entire independence of its income and its necessary expenditures. This is the case even with institutions like Cornell University, for example, with its millions invested. Not only do its opportunities widen faster than its income increases, but its varying income has absolutely no even approximate relation to its needs. The larger universities of this class, which are mainly in the East, are always needy, and the wealthier they are, the more needy are they; as it is invariably the fact that they expand as rapidly as physically possible, and endowments provided, however largely, find even more prompt and more effective application than in the smaller colleges. They afford the largest and most efficient opportunities for philanthropic investment, but rarely are given enough in any one endowment for the purpose specified as that to which such endowment is to be applied. Their 'general funds' are invariably depleted to bolster up the temporary or permanent needs of endowed departments, and the trustees are always embarrassed by deficiencies in the general account. Only those institutions which receive ample and regular income from the state for the regular and essential expenditures, and in which private munificence finds its field in adding the desirable but unessential, the comforts and the luxuries of higher intellectual life, are certain of permanent and satisfactory success in their most vital work. The tendency toward a support of the universities, their foundation and adoption, by the state, as illustrated now so generally among the states west of the Hudson, is thus obviously to be regarded as one of the most encouraging and reassuring signs of the times. These states are carrying into effect the plan of education of the people for the work of the people which must constitute a main element in our future progress."

Engineering as a learned profession is thus, by the logic of events, coming to be largely dependent for its fullest development upon the state systems of higher education. The independent schools are likely long, perhaps always, to be prominent, and even often to be pre-eminent, in the promotion of the highest phases of engineering education; but the great work, as a whole, must, sooner or later, devolve, it would seem, upon the state universities in the West, even if not in the East. This is especially true of this branch of technical education; since it is coming to be recognized as essential to the success of such professional schools that a large and costly equipment, both for illustration and for research, must be provided, if they are to take their rightful place in the lead of the profession which they are to serve; and such equipments can rarely be provided by private endowment; they can easily be secured by public appropriation. The great technical school, and especially the engineering school, of the present and of later times must be prepared to instruct its students in all the sciences underlying the profession of engineering, and, still more, and still more important, if possible, it must promote the acquisition of new facts, new scientific laws, and of new technical and professional learning, by complete provision for systematic research in every field of scientific and engineering work.

The curriculum of the modern strictly professional engineering school is, in its best examples, I take it, purely professional. It includes instruction, simply, in such sciences, in such branches of art and industry, as contribute mainly and necessarily to the work of the engineer. Educational work, as such, has no proper place in the curriculum of the professional school. That should be done, and completely, in advance. Such literatures and such languages, only, fall into the scheme, properly and naturally, as contribute to the engineer's technical and professional stores. A complete line of advanced mathematics, pure and applied; so much of the physical science of the time as constitutes a part of the fundamental basis of his professional training; instruction and training by practice in the art of the draughtsman and in the mechanical and industrial arts; applications of mathematics and the sciences in machine design, and in the computation of the probable efficiency and performance of his machines and apparatus of manufactures; and, finally, the methods of determination, by experiment, with every scientific aid, of the value of such machinery in its actual use, and still higher applications of scientific method to the prosecution of original investigations of engineering problems and of research looking to the acquirement of new and useful facts and principles in science and in every department of his work; these are the purposes and the proper field of the professional school of the engineer. The technical school, of whatever grade, must necessarily begin where the possibilities of the time and location may place it, and must start its work where the lower schools are able to furnish preparation; but this, our ideal, professional school is the final and highest end in its development, and every state university will, ultimately, be expected to approximate the ideal as its means and its constituency shall make it possible. When, after providing elementary instruction and essential professional training in the theory, and the contributory arts, of engineering, it can, without sacrifice of those primary essentials, reach up into the realm of scientific research, and can begin to contribute its share in its proper departments of human knowledge, it will have attained the grandest of all its great purposes. It is then that it will begin to lead the people into that higher and nobler province of material development which is the end and aim of highest modern technical education. Then it will contribute most effectively to the progress of the nation.

The state university must, eventually, become the great center of intellectual movement for the whole state, stimulating the best and noblest work of the best and noblest minds in every department of so-

cial, economic and political life; doing for the state what Washington and Jefferson and Madison and the Adamases hoped to see accomplished, if possible, on a still loftier plane by that great "national university," of which every statesman from the foundation of our nation has anticipated so much as the grand central national educational institution; constituting, as they hoped, the loftiest element of a system of "liberal and practical education" of the whole people for all the best purposes of the people's life.

A national university would find proper and useful work in the unifying of the systems of the states, in furnishing great men to conduct the work of the state universities, in giving opportunity for that highest work of investigation and research, in all departments of human knowledge, which may be so effectively promoted through the utilization of that marvelous collection of literary, scientific, professional and special institutions which have their natural home at the capital of the nation. As Governor Hoyt has said:

"There are at Washington, in all departments of the government, nearly a thousand experts in a great number of classes or branches of service, from the shops in the navy yard to the Supreme Court itself; the whole body constituting the most important cluster of men of genius and rare attainments in the world. Hundreds of these men could serve a great university, either as lecturers and instructors, or by furtherance of its scientific work in some other way, thus greatly aiding it, while also adding something to their very moderate regular incomes, and gaining new inspiration for still better service in their usual rounds, if not, indeed, for the supreme work of new discovery. For a great and powerful nation to allow all these vast and varied resources to remain indefinitely without the fullest possible use in the interest of science and learning, while at the same time multitudes of its citizens are suffering irreparable loss for want of them, is incomprehensible. It is certainly the worst economy conceivable, and seems hardly less than criminal."

Dr. B. A. Gould, in his Phi Beta Kappa address of 1886, said:

"An intellectual center for a land is a heart, but subject to no induration; it is a brain, but liable to no paralysis; an electric battery which cannot be consumed; it is a sun without eclipse, a fountain that will know no drought. To such a university our colleges would look for succor in their need, for counsel in their doubt, for sympathy in their weal or woe. There is no one of them but would develop to new strength and beauty under its genial emanations; none so highly favored or so great that its resources and powers would not expand; none too lowly to imbibe the vitalizing, animating influences which it would diffuse like perfume."

As I have had occasion elsewhere to say: "A national university naturally crowns and completes a system of national education. The states of the Union supply all the elements, or are rapidly coming to do so, of the primary and secondary education of the people. They are also all rapidly coming, through a generous and wholesome rivalry, to a common and high standard of education in every grade. There is thus nothing left for Federal government to do but to place at the head of and above the whole great educational system of our united system of states that greatest of universities, a national university, in which shall be collected the greatest men of the nation in their respective departments, to give instruction to the ablest students that the universities of the states may supply. Such an institution would necessarily and appropriately be one mainly for the promotion of research in every branch of learning and to give instruction to instructors in all departments of the pantology. Thus planned and thus conducted, with the wonderful resources of the general government and all the great collections in science and in literature aggregated at the capital at its disposal, such an institution would magnificently complete the whole national pyramid, by giving it such an apex as the world has never yet gazed upon. This great scheme was first proposed by George Washington and his colleagues, a century ago, and was urged upon a busy and distracted people by Madison, Jefferson, and every other great political or official representative of the government or of the nation, up to the times of Lincoln and of Grant, who were earnest in its favor. But the times were not ripe for it. To-day is the time for the harvest. The completion of the curriculum, by the introduction of the elements demanded for the 'complete and perfect education' of the people, and the completion of the system of educational institutions of every grade from the lowest primary school to the national university in which are to be prepared the teachers of the teachers of the community, fittingly come together, and the complete and perfect educational system of a nation may now, for the first time, take form. It is two thousand years since, in the days of Hero, of Archimedes, of the disciples of Aristotle, and of Herodotus and of Hypatia, a first attempt was made to found a real and complete national university in which should be illustrated all phases of human knowledge, not excepting the at times despised departments of technical and professional training, of education and research, which may be reasonably looked for in view of the advancing tendencies of the time, we may hope to see the best possible safeguards established for our whole system of technical work."

Dr. Dollinger, in an address, some years ago, before the Munich Academy of Science, remarked that, in his opinion, "the main hindrance to literary and scientific progress in the United States is the want of a great central university." He thought that the perfection of a system of educational centers and institutions, having a common plan and being parts of a common organism, each doing its share and doing it well, would prove to be the only efficient means of attaining this end.

Since the days of the Alexandrian university, two thousand years ago, as I have said, there has never yet been seen a true and all-comprehending university. The work of the state universities, as they are here and now developing, will, for the first time, since the time of Ptolemy Philadelphus, illustrate such a "complete

and perfect" scheme of education, and they, with the coming national university, will, ere long, we may hope, give to these United States perfect union of all the sciences, all the arts, all the literatures, and all the applications of highest human knowledge, in the promotion of the greatest interests of the people. We are coming to see, in such great enterprises as this to which we are to-day giving inception, a grand step toward the perfection of engineering as a learned profession, and especially in the provision of that widest education "which is the only interest worthy the deep, controlling anxiety of the thoughtful man," and in such form and symmetry and completeness as comports worthily with the magnitude and might of the greatest of modern commonwealths. The Learned Profession of Engineering is but a single unit in a complex and mighty whole.

May this materialization of "the dreams of great men" soon give our country that foundation of wisdom and knowledge, and of righteous and intelligent life, which only can form the true basis of permanent and highest prosperity! May this, a true "People's University," contribute its full share to the grandest work of modern times: that education of the youth of our country which is the real upbuilding of our nation.

EARLY STEAM ROAD LOCOMOTIVES.

THE propulsion by steam power of vehicles traveling on common highways has recently been somewhat prominently before the public, and several modern designs of steam road carriages have been submitted as being suitable for locomotion on common roads. Some few of these possess points of undoubted utility, but the remainder of them vary from good to indifferent, and even extreme unsuitability. That a means of traveling on ordinary roads by motive power other than that supplied by animals, biped and quadruped, is required is evident by the intelligent opinions expressed on the subject by a very large number of people who have in some way or another shown an interest in the matter. An historical sketch of the early steam locomotives will, therefore, we think, be of general interest at the present time. As patriotic Englishmen, we cannot but give the claim of Dr. Robinson the first place in the development of steam locomotives. It was in 1759 that he communicated his ideas of a steam carriage to Watt, who was at that time busily engaged in developing the steam engine, principally in connection with pumping. Watt, however, did not give the proposal any serious attention, although models were constructed.

France, however, had the honor of providing the first self-propelling "land carriage," which Nicholas Joseph Cugnot produced in 1769, and in 1771 the same inventor constructed a large engine which is even now exhibited in the Conservatoire des Arts et Metiers at Paris. The French government was favorably impressed with Cugnot's invention, and provided the money to build this second locomotive; but after the machine, which could only work for about fifteen minutes at a time, had made a few trips in the streets of the French capital, it was, unfortunately, upset; then the government packed it away in the arsenal, and nothing further was done to develop steam road locomotion in France. This land carriage had three wheels, the motion being communicated to the front one by means of a ratchet wheel. There are two single-action vertical cylinders, 13 inches in diameter, the admission of steam to which is controlled by a four-way cock. The copper boiler is hung in front of the carriage, and there are two flues from the firegrate. On a level road this machine traveled at the rate of 2½ miles an hour.

The Americans commence the history of steam locomotion with the steam wagon built by Oliver Evans, of Philadelphia, which he patented in 1782. In 1784 Watt took out a patent for a steam road carriage, and it was from this specification that Murdoch, in 1785 or 1786, built the steam monster which so frightened the worthy vicar of Redruth when he saw it careering up the lane by the church one evening. Watt's idea of either the power of steam or the pressure necessary to drive a vehicle at this time appears to have been of rather an elementary kind, for in a letter he explains his notion of a boiler thus: "The boiler to be of wood or thin metal, to be secured by hoops, or otherwise, to prevent its bursting from the pressure of steam." The Cornish firm of Messrs. Tangye Brothers, of Birmingham, possess a model made by Murdoch. This is a three-wheel vehicle, the steering being done by means of an arm attached to the front one. Below the frame and at the back of the rear axle is the firegrate. On the frame above the boiler is fixed, in which the one vertical cylinder is partly immersed, the piston rod of same being attached to a beam, to which is connected a rod which actuates the driving wheels by a crank axle.

An inventive Scotchman, William Symington, in 1786 constructed a model of a steam carriage, which was exhibited in Edinburgh, and in 1795 he built a steam engine, and used it upon a turnpike road in Lanarkshire. The South Kensington Museum contains a model constructed by that Cornish genius, Richard Trevithick, the father of the railway locomotive. Trevithick and his cousin Vivian took out a patent for the application of high-pressure steam to propel a steam carriage in 1802.

The locomotive constructed by this inventor, and used on the Merthyr Tydvil tramroad, not meeting with public support, Trevithick came to London, and toward the end of 1804 or early in 1805, by the help of several influential patrons, he fitted a phaeton with a small steam engine, and from the following account this seems to have been rather a success: "The engine he used was about the size of an orchestra drum, and which he attached to a phaeton between the back wheels. With this carriage an experiment was made in Lord's cricket ground, at Marylebone, several men of science alternately steering it, and expressing their perfect satisfaction as to the ease with which it was directed. From there it was steered down the New Road and Gray's Inn Lane to the coachbuilder's whence the phaeton was obtained. The next day Trevithick took this engine and exhibited it in a cutler's shop, working the machinery, which was one of his essays to show its general applicability. Subsequently he had a temporary tramroad constructed within an inclosure on the ground now occupied by Euston

* Technical Education in the United States, World's Engineering Congress, Chicago, 1893; Trans. Am. Society Mech. Engrs., vol. xiv., 1894.

* Report on a National University.

† Technical Education in the United States; Trans. Am. Soc. M. E.; 1893.

Square. This road was of an elliptical form, and on it he ran his locomotive. It was opened to the public as an exhibition, and people crowded to see it, but the second day Trevithick, in one of his usual freaks, removed the engine, and, to the great disappointment of the visitors, closed the ground. This he did under the impression that it was better to let the affair drop until he saw the opportunity to avail himself of it advantageously."

During the next fifteen years various experiments were being made by different enterprising individuals to produce a coach driven by steam, able to travel on the ordinary turnpike road, and in 1821 Julius Grifflith, of Brompton, designed a vehicle to carry both goods and passengers. The machinery was at the back, and comprised a pair of vertical cylinders, a boiler, furnace and condenser, the propelling power being communicated to the rear wheels by means of toothed wheels. About this time Messrs. Hill & Bursall, of London, built a steam coach which traveled at the rate of 3 to 4 miles an hour. After several experiments, however, this vehicle was discarded in consequence of the many defects found to exist in the boiler.

In 1824 a Mr. W. H. James prepared designs for a steam road vehicle, and in 1826 built a very successful one. This coach made several journeys, and the propulsion was obtained in a twofold manner, viz., by means of a crank axle, on which were the rear wheels, and partly by means of legs which were placed upon the ground, the steam forcing the vehicle along much in the same way as a person in a punt propels himself through the water. About the same time Mr. D. Gordon equipped a steam coach, which was entirely propelled by means of these legs.

steam pressure of 50 pounds, was built. The inventor provided this vehicle with an extra safety valve of a novel kind, viz., a piece of sheet lead of the thickness of brown paper, which was secured over a small nozzle on the top of the boiler, the inventor claiming that when the steam was sufficiently powerful, it would burst the sheet lead, and so save the boiler from blowing up. This carriage was to be capable of ascending an incline of 1 in 3, but there is no definite record of the Triumph having performed this feat.

In the same year, a mechanic at Hoxton, named Lea, constructed a model of a steam coach, which was "capable of accomplishing everything that a horse could do on any road or in any season." It was not in England alone that attention was given to this method of traveling, for the *Mechanics' Magazine* of July 3, 1830, contains this paragraph: "It is stated a steam carriage will shortly ply between Dresden and Leipzig. Is it possible that we shall, after all, permit foreigners to anticipate us in the public use of this noblest of all the results of steam machinery?"

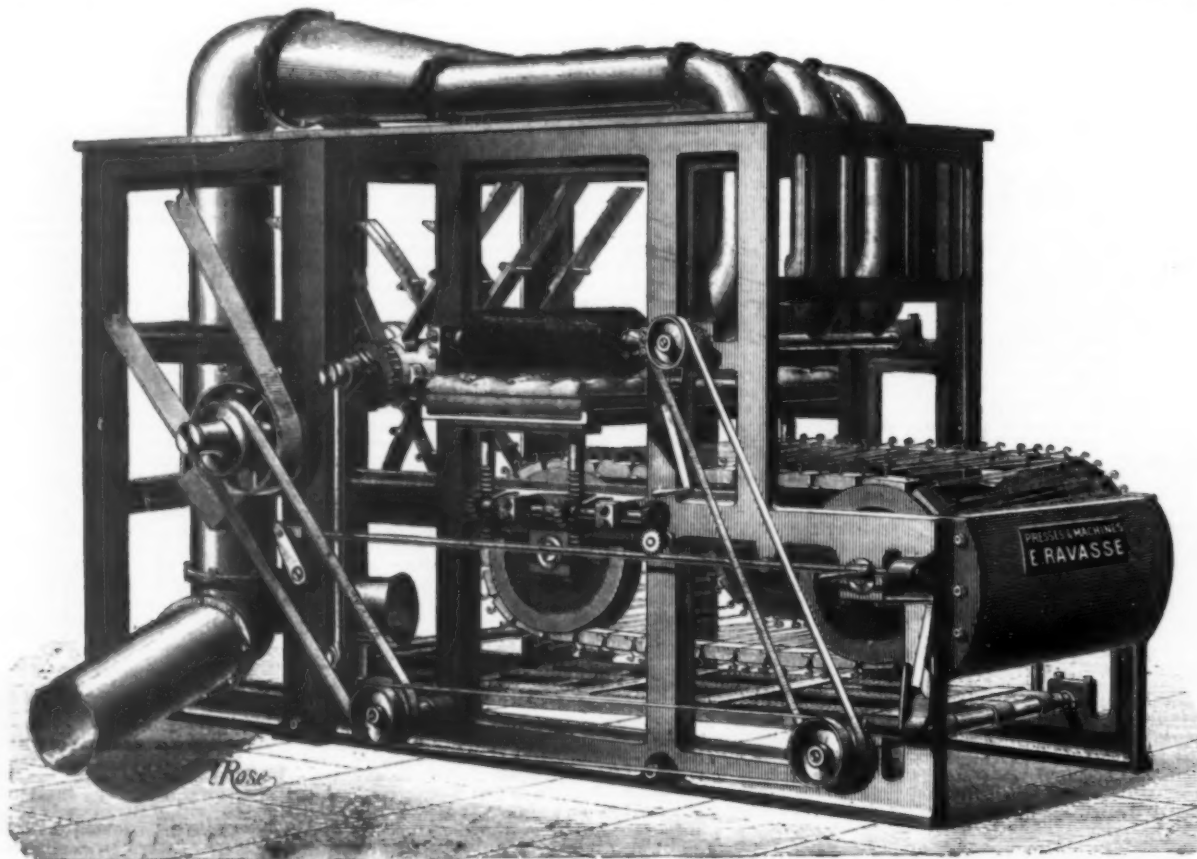
But even after railways were firmly established, there were many who still favored steam road coaches, and energetically endeavored to bring them into general use. Sir James Anderson, an Irish baronet, was one of the principal supporters of this method of locomotion, and spent over £30,000 upon the project. In 1839 a company called the Steam Carriage and Wagon Company was formed. Dawson, of Dublin, built a vehicle for the company, under the direction of the baronet.

In 1839 a Mr. Hancock built a coach which was to travel between London and Cambridge. It made its first journey on Monday, September 30th. We read that "this carriage left the Four Swans, Bishopsgate Street, at 10 o'clock in the morning. The time in ac-

RAILWAY CARRIAGE CUSHION CLEANER.

A CORRESPONDENT recently asked for the names and addresses of makers of carpet beating machinery; and M. E. Ravasse, of 99 Rue de Crimée, Paris, makes a machine, designed by M. Bricogne, locomotive and carriage superintendent of the French Northern Railway, that not only beats the carpets of railway carriages but also brushes the cushions while drawing off the dust. The machine, shown by the accompanying perspective view, from *The Engineer*, will, with the attendance of one man, clean 350 carpets or cushions in an ordinary working day, while this number could be considerably exceeded if the carpets and cushions were not so dirty as they generally are after a long run.

As will be seen by the engraving, the machine consists of two side frames strongly braced together, and for the most part glazed, so as to form a chamber for confining the dust raised by the beaters and brushes within the influence of the fan, which draws it off by means of galvanized iron pipes. The carpets are attached to the endless band traveling over the two drums seen to the right of the figure; and the surface of the band is formed of cords passed backward and forward and between the hooks seen on the traveling chains, thus affording a good elastic surface to receive the blows of the beaters. The latter consists of twelve stout leather straps fixed on the iron arms of a horizontally revolving drum. The table for receiving the cushions travels backward and forward transversely to the direction of the carpet band, and may be adjusted to suit the height of cushion, by means of four racks. The brushing is effected by two cylindrical brushes, one of which may be seen in the engraving. The beater, the traveling band for the carpet, and the



NEW RAILWAY CARRIAGE CUSHION CLEANER.

The system of traveling on roads by means of steam coaches was at this period being rapidly developed, and had the Liverpool and Manchester Railway been even but a qualified success, it is more than likely that steam coach traveling would have become firmly established as our national method of locomotion, in place of the railway as since developed. But the great factor that operated against the general introduction of steam coaches was the exorbitant tolls charged by the farmers of the turnpikes on the various high roads, who took advantage of the fact that steam locomotives were not mentioned in the schedules allowed by Parliament to exact most prohibitive tolls. On one road the charge was 1s. 6d. per horse power of the engine; another gate, which only levied a toll of 4s. for a stage coach, mulcted a steam coach to the extent of 48s.; while the fact that there was no settled charge made traveling by means of steam power most inconvenient for the owners of these vehicles. Thus at one gate the toll might be 5s., while at the next bar the driver might be called upon to pay £2 for the same coach. So glaring did the abuse of extortionate tolls become, that in 1832 the House of Commons appointed a select committee to inquire into the charges levied by the various turnpike toll keepers for the use of the roads by steam coaches.

In 1829 Gurney ran his steam coach from London to Bristol and back, and succeeded in covering the 84 miles from Melksham to Canford Bridge in ten hours, including stoppages. The maximum speed attained on this trip was at the rate of 30 miles an hour. A steam coach was running at this time between London and Southampton; it weighed less than three tons, including the machinery, fuel, and 14 passengers; it was of powerful design, and climbed an incline of 1 in 6 at 16 miles an hour; while for four miles on a level road, it maintained a speed equal to 24 miles an hour.

In 1830 the Triumph, with a single cylinder, 6 inches in diameter and 18 inches stroke, and worked at a

usually running the 52 miles was 4½ hours, and the first 30 miles, including Wade's Mill Hill, was performed in 2½ hours (the first two miles being through the streets of London), which is at the rate of 12 miles an hour."

After this we hear but little more of steam road coaches; even those who had for some time urged the superiority of this method of traveling came to the conclusion that, at any rate for passenger traffic, coaches propelled by steam power had no possible chance in competition with vehicles on the iron roads, while all remaining hopes of such traffic were effectually destroyed when the legislature passed an act rendering it necessary for a man to walk in front of a road locomotive, exhibiting a red flag, and limiting the speed to four miles an hour. It is true that steam traction engines are employed in a few districts for the purpose of hauling heavy loads between places where there is no railway accommodation, or where that provided is not so good as it should be, but the traffic so conveyed is but an infinitely small fraction compared with the volume carried by the railways. The question of allowing private vehicles to travel on the highways, propelled by steam or other motive power, is one that is likely to be rather prominently before the public before long. There can be no doubt that modern invention and enterprise would soon provide both cheap and efficient vehicles suitable for the requirements of to-day, if the present grandmotherly legislation on the subject were repealed, and sensible laws enacted which duly provided for the safety of those using the highways, and yet allowed vehicles propelled by steam or other power to use the roads under somewhat the same conditions as horse-drawn conveyances are placed at the present time.—*Practical Engineer*.

THAT which is popularly known as the funny bone, just at the point of the elbow, is in reality not a bone at all, but a nerve that lies near the surface, and which, on getting a knock or blow, causes the well known tingling sensation in the arms and fingers.

cushion brushes may all or any of them be thrown out of gear at will.

THE STROOBANTS PRISM TELEMETER.*

This instrument consists of two small glass prisms, A and B, placed base to base, as in Fig. 2, and inclosed in a light case.

Each prism has a right diedral angle at r (Figs. 3 and 4), but the opposite angles s , which are cut off in order to save space, differ in value, that in prism A being 45° and in B $45^\circ 22' 55''$.

The faces of the right angles are alone uncovered; those forming the angle r are carefully silvered, and thus form two couples of mirrors protected by the case.

The prism, A, enables us to construct a right angle abx at the end of a line ab (Fig. 6).

The luminous ray from an object, a (Fig. 3), enters the prism, is doubly reflected on the silvered faces and leaves the prism at right angle to its original direction, and therefore without refraction. The eye at O sees the object, a , in the direction ba' , the angle aba' being 90° .

Practically a stake is driven at b (Fig. 6), the distance ab being the one we desire to measure. The observer at b takes the prism between the thumb and first finger, turns his body so that his left shoulder is toward a , revolves the prism, A, horizontally till the object a is seen by reflection. He then glances over the case and causes a stake to be driven, or selects some object, in the direction which the object, a , appears by reflection. The angle aba' is 90° .

The prism, B, enables us to construct the angle $91^\circ 5' 45''$. The luminous ray enters as in the previous case perpendicular to the face, rp , and is doubly reflected by the silvered faces, so that the angle at I (Fig. 5) is $2 \times 45^\circ 22' 55''$ or $90^\circ 45' 50''$. As this ray does not leave the prism perpendicularly to the face, rm ,

* Translated from *La Belgique Militaire*, by Lieut. J. C. Bush.

we must take into account the index of refraction—about $3/2$. Hence $\sin \alpha' = \sin \alpha = 90^\circ + 3/2$ ($45^\circ 50'$) = $91^\circ 8' 45''$.

Thus the eye placed at O sees the image of the object, a , in a direction oa' , which makes with the incident ray, ac , an angle of $91^\circ 8' 45''$ and permits us to construct this angle.

The right angle having been determined as previously described (Fig. 6), the operator now turns the instrument end for end so as to bring the end, B, to the eye. He then advances along the line, ba' , till at some point, c , the reflected image of a appears to coincide with the stake or object at a , determined by glancing above the prism as before. The angle aca' is $91^\circ 8' 45''$. The base, bc , is then measured, when the distance ab will be found equal to $50 \times bc$. $Ab = 1 \times bc$.

The angle a being $1^\circ 8' 45''$, its tangent is $\tan a = \frac{1}{50}$, hence $ab = 50 \times bc$.

The index of refraction may not be exactly $3/2$, and

THE USE OF CORK AS A BUILDING MATERIAL.

By S. SAMPOLO.

STUDIED in its qualities, cork is one of the lightest and the worst conductors of heat and sound substances. It is also somewhat elastic, and when moderately compressed does not absorb water. These evident properties have for a long time given a great extension to the use of cork for industrial purposes, principally for the manufacture of stoppers for any kind of vessels containing liquids which do not attack organic substances.

Everybody knows that cork is the bark of a particular oak growing, not in America, but on the coasts of northern Africa and southern Europe. After being deprived of its hard, non-elastic and useless elements, this cork bark is cut into square pieces and turned on a special lathe, where the stopper shape is acquired. In this manufacture the waste should, theoretically, be about 20 per centum; in fact, how much larger is the quantity of scraps thrown away by the machine? It is an interesting industrial problem to try and make the best use of them in a judicious way.



Figs. 1. and 2.

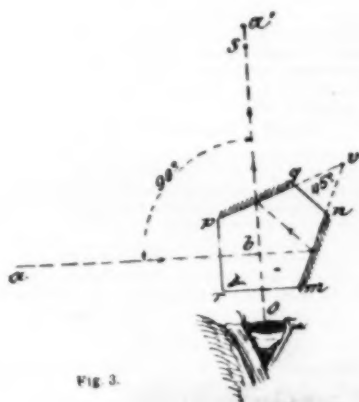


Fig. 3.

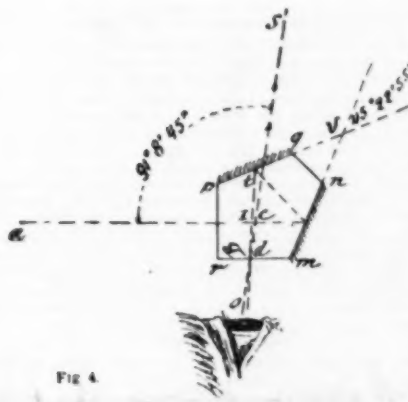


Fig. 4.

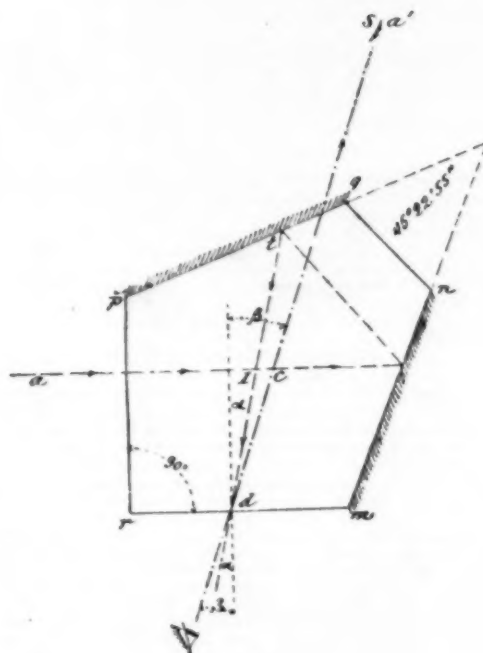


Fig. 5.

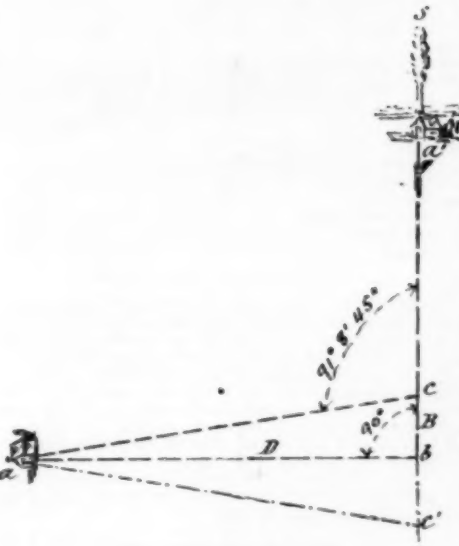


Fig. 6.

THE STROBANTS PRISM TELEMETER.

In grinding the prisms a small error of one or two seconds may be made in the angles, which would affect the coefficient 50. In order to correct these errors the prisms are carefully tested and the exact coefficient determined and marked on the cover of each telemeter, as $D = 50.6 B$ for example.

The instrument is carried in a light case, on the cover of which the distances corresponding to the bases are tabulated.

The telemeter is only about $1\frac{1}{2}$ inches long by $\frac{1}{4}$ inch thick, being smaller than the Souchier telemeter adopted by the Russian government. It is accurate, simple, unalterable, easy to manage and quite inexpensive. It can be applied to a field glass in a manner similar to the Souchier by means of a cover to the object glass and a clamp.—*Jour. Military Service Institution.*

So far, the only important application of this refuse material has been made in the manufacture of linoleum, which can not utilize but a small percentage of the waste. Render possible the introduction of cork refuse for building purposes, and at once all scraps and cuttings will find an important application. If, at first, the idea may not appear realizable on account of the little resistance of cork, we may say that thousands and thousands of bricks and tiles have already been made in France with pulverized cork refuse, and have worked satisfactorily. Labor and patience have not been spared, and strengthening cements, which can be poured into any shape, size, and thickness, have been in use.

Two kinds of cements can be manufactured; the first containing powder or small pieces of cork, plaster of Paris, dextrine, and sesquioxide of iron. The second,

besides all those substances, also contains an oxychloride such as the oxychloride of zinc, which makes that composition perfectly water-proof. Like cork itself, these cements are non-conductors of heat and sound; they carbonize without giving any flame when exposed to a high temperature, do not decay, and absorb very little or no water. Moreover, this product is better than cork, because of its great resistance to compression. Experiments have been made, and it is now demonstrated that the bricks begin only to crack under a pressure of 190 pounds per square inch. Therefore, if, with the cements, bricks and tiles are moulded or concrete is poured off, we will obtain very valuable building materials, the main applications of which we will examine here.

1st. Every time heat or cold is to be kept in a room, or a heated or cool pipe or other recipient, cork refuse may be used with advantage. The coefficient of conductivity of heat determined by Pietet for cork is 0.143 in French measures, which will be used now for convenience sake. To demonstrate how comparatively small is this figure, and therefore how efficient would be the use of that material for such a purpose, we will calculate the quantity of steam condensed per hour in a steam pipe insulated with a 1 inch thick covering (0.035 gramme).

For example, let us assume a pipe 0.10 m. in diameter, the live steam being at a temperature of 135° Cent. and circulating at a speed of 40 meters per minute, the temperature of the room being supposed to be 15° Cent. The quantity of steam passing through that pipe for one meter of length is per hour:

$$1.35 \times \frac{3.14}{4} \times 0.10^2 \times 1 \times 40 \times 60 = 23.40 \text{ kilos.}$$

If we neglect the radiation and convection, the quantity of heat lost for that surface of pipe will be:

$$3.14 \times 0.125 \times 1 \times 0.143 (135 - 15) = 24 \text{ calories and } \frac{1}{60}.$$

And as 1 kilo. of steam gives out by being condensed 600 calories, in round numbers, the percentage of steam lost will evidently be:

$$\frac{24.6}{600 \times 23.40} \text{ about } \frac{1}{600} \text{ or } \frac{1}{6} \text{ of 1 per cent.}$$

These figures show all the benefit we can derive from using cork refuse for boilers and pipe coverings, and also for building purposes. Many a time, in a light construction, the loft is not habitable on account of the differences of temperature which tenants would have to support. Cork tiles nailed on inclined joists and on ceiling boards would make this loft as comfortable as any other story of the flats. In hot countries, for instance in Algeria, where heat is considerable during the summer, they use now cork tiles to coat the walls inside, and Russians are also protected in the same way from cold. In a word, there are numerous applications of this material as a protection against heat and cold.

2d. As has been already mentioned, cork material does not conduct sound. We will give you an example of this, as we had occasion to observe it in Paris. It was in the Menier House Festival Hall. That house, six stories high, was occupied by different tenants, and the use of the hall for meetings and private parties was quite objectionable to them on account of the disturbing noise at night. By replacing the plaster ceiling by cork concrete, all objections were removed. This fact proves how much sound deafening is a cork concrete floor, and how useful it will prove to have such a material where quietness is required, as in library reading rooms, telephone closets, etc.

3d. A third important property of cork compositions is to attenuate the vibrations to a great extent; for instance, when near engine or dynamo rooms are located places where vibrations can be troublesome, like in drawing-rooms or offices, and especially in rooms where crystallization of certain salts is carried on. In fact, crystallization is always disturbed and sometimes prevented by a constant trepidation; and we quote a circumstance in which, having to produce chrome crystals, the manufacturer had to leave the town and go to a quiet country place to carry on his work. A cork floor would have saved all that trouble.

In regard to elasticity of cork, I will mention here the following happy application of that material. To prevent dampness in a gunpowder factory, all walls had been protected by a cork brick coat, and all partitions had been made with cork tiles. One day they had a terrible explosion, as dangerous as they are sure to be in such cases. If the walls and partitions had been in stones or bricks, the loss of life would have been serious. The cork product (after having greatly slackened the vibrations) crumbled to powder, and only a shower of small pieces of harmless cork dropped on workmen, and no one was injured.

4th. Lightness and waterproof quality have now to be spoken of. In a country like the United States, where high buildings are getting in favor, light partitions are a very desirable device. Everything has been tried in that line, and a quantity of materials have been worked on. Among all these, porous brick is as yet probably the best. But cork tile is a great deal lighter. The specific gravity of porous brick is represented by 0.70 , when that of cork brick is only 0.38 ; that is to say that nearly half of the weight is saved. I will merely mention here again the importance of waterproof material in cellars, basement walls, bath rooms, etc.

5th. Is cork fireproof? That is the question of today. Insurance companies will not take any risk for the highest stories on account of the difficulty of extinguishing fire; and, of course, fireproof material is carefully looked for. Positively, there is no entirely fireproof material. Brick partitions crack and flames can spread out in every direction. What should be required from a partition is that it shall not propagate fire. Cork cement answers the purpose, as it carbonizes very slowly and gives out smoke but no flame.

Such are the principal qualities of cork and its compositions. To be complete, I must mention the possibility of its being used for decorative effect. Cork being ground into impalpable powder, all details of an engraving can be exactly reproduced. In writing the

foregoing, my desire was to attract the attention of architects and engineers to the utilization of pulverized cork refuse; and if I have succeeded, my aim has been reached.

OUR AMERICAN SCHOOLS—THEIR PROGRESS, CONDITION, AND PROSPECTS.

FACTS AND STATISTICS OF PUBLIC AND PRIVATE SCHOOLS, OF HIGH, NORMAL, SPECIAL AND PROFESSIONAL SCHOOLS, AND OF UNIVERSITIES.

THE report of the United States Commissioner of Education for the school year 1890 and 1891, just issued, consists of two volumes having 1349 pages of printed matter. Without exception this report is the ablest one ever issued by the Department of Education, and it is replete with information of deep interest to the educational world. We are largely indebted to this report for data used in calculations which approximately show some of the results of the school work of the country for the school year ending June, 1894, and convey an idea of the magnitude of our school system.

VALUE OF SCHOOL PROPERTY.

In 1890 the value of our public school property alone was \$343,000,000, and in July of 1894 the value had reached \$400,000,000. A careful estimate of the value of all the property, buildings and grounds, libraries and apparatus, endowments and investments for educational purposes in the United States, inclusive of public, private, church and special schools and colleges, places it above \$600,000,000.

OUR PUBLIC SCHOOL SYSTEM.

This system educates a people far beyond its few school books and thus broadens its own pathway. The ordinance of 1787 recognized the necessity of schools and colleges, and in the form of a perpetual compact between the general government and the people of the States has always been an encouragement to educational effort. The duty of the State to educate her youth to the fullest degree to which her youth are able to receive education can never be disregarded without a violation of the pledges upon which the State was founded. As private enterprise is limited by its private and special end, it cannot be safely depended upon to attend to the work of general education. Public aid and control are necessary to prevent hurling changes and interruptions. The free State can have no guarantee of its own life even, save in the intelligence of its citizens. The corporate and the individual life must be of the same kind, as the State is nourished by the lives of its citizens. This is especially true of a republic, for this form of civil rule cannot rise above the best intelligence of its citizens. The free State requires much of a citizen, making him a voter, a juror, a legislator, and demanding that he shall be a useful and productive factor in society. In these public demands upon him lies his claim upon the State for an education to fit him for the best performance of his duties. But as the individual passes away, his children take his place, hence the process of fitting individuals for useful lives, or the process of education, must be a continuous one. Property, too, is no more nor less than a creature of intelligence; it scarcely exists among savages, and exists in small degree in unenlightened lands like Persia, Turkey, and most portions of China. The duty of a free State to see that its citizens are educated is fundamental and cannot be delegated. Other agencies all lack the means and motives for doing this work and are not universal in their operation. The power and wealth of the State alone can provide and maintain the machinery of complete education and have it, to a proper extent, reach all. The general education of the young is now admitted the world over to be the indispensable element of assured progress.

PUBLIC SCHOOL ENROLLMENT.

The following tabular statement gives the total enrollment of pupils in all the public and private schools of the country, for the school years ending with June, 1891 and 1894:

	1891.	1894.
In elementary schools...	14,146,663	15,416,000
In secondary schools...	370,435	408,000
In higher schools.....	151,971	176,000

Private schools and colleges enrolled 11 per cent. of the total enrollment. In the elementary grades 90 per cent. of the pupils were enrolled in the public schools and 10 per cent. in the private schools. In the secondary schools those of a private character had 40 per cent. of the enrollment, and in the higher departments they had 70 per cent., and the public colleges had but 30 per cent. Out of every 1,000 pupils and students enrolled, 964 were getting primary and grammar school instruction, 26 were in the high school department, and 10 had entered upon college and professional studies. The total of our present school population, or of all persons between six and eighteen years of age, is 20,000,000, or 29½ per cent. of our total population of 68,000,000. The school year dates from September 1 to July 1 of the following calendar year. In the cities of the country the school year usually consists of ten calendar months, the schools being in session five days in each week or 200 days in all. The remainder of the year is used for vacations. During the past six years the average length of time per year in which the schools of the whole country were in session has been 133 days. It was 135-7 days in the year 1891, and 136 days for the year ending June, 1894. Country schools, as a rule, are in session from 70 to 150 days during the school year.

AVERAGE DAILY ATTENDANCE.

The average daily attendance of pupils in all the schools for 1890 was 8,144,938, for the year 1891 it was 8,329,234, and for 1894, 8,250,000, or about 45 per cent. of the school population between six and eighteen years of age, or 56 per cent. of the total enrollment.

TEACHERS.

The number of persons employed as teachers in the public schools of the whole country for the school year of 1889 and 1890 was 363,935, for the year 1890 and 1891 it was 364,791, and for the year ending June 30, 1894, it was 384,000. About one-third of these teachers were

men. The average monthly salaries paid teachers in 1890 and 1891 was \$45 for men and \$37 for women. In 1894 it was \$47 for men and \$38 for women. In the private schools of the country there are not less than 60,000 teachers, which number added to 384,000 gives 444,000 as the total number of teachers in public and private schools for the year.

RECEIPTS FOR PUBLIC SCHOOL PURPOSES.

For the school year ending with June, 1894, the receipts from all sources for the support of public schools amounted to \$160,000,000. About 6 per cent. of these receipts are derived from permanent school funds, 19 per cent. from State taxes, 68 per cent. from local taxes, and 7 per cent. from all other sources.

The number of taxpayers to every 100 persons of school population varies greatly, being five times as many in some localities as in others. In the whole United States there are 91 taxpayers to provide the means of education for every 100 children of school age. In the south central States, however, there are only 66 adult males to provide the means for educating 100 children, while in the States of the western division there are 157 adult males to every 100 children. In South Carolina the number of adult males for 100 children is only 53, and 33 of them are colored. In Montana there are 275 adult males for every 100 children of school age. All other conditions being equal, each taxpayer in South Carolina has to pay five times as much as a Montana taxpayer to duplicate the educational conditions. The curious inequalities of school taxation are shown in the fact that Montana raises \$3.85 per taxpayer, which furnishes \$16.02 for each child of school age, but Texas raises a larger sum (\$6.55) per taxpayer, but has, as a result, only \$4.48 for each child of school age, and each dollar paid in Montana goes as far in effective work in supporting the public schools as \$4 goes in Texas.

IN THE SOUTH.

The progress of public education among the colored people of the South, where there are as yet only a few adults with a minimum of property, is very gratifying. Counting white and black taxpayers, they raise for school purposes alone one-half what is raised at the North per taxpayer, and they realize from one-third to one-fifth of what the North has per child of school age; and, further, they enroll nearly as large a proportion of their school population as the North does, and have a school year two-thirds as long as that in the North. The day is not distant when all the Southern States will make ample provision by local taxation for a better support of public schools. In Massachusetts 98 per cent. of the ample school revenues are raised by what is virtually local and voluntary taxation. Every dollar put into public instruction comes back to the State increased a hundred fold in the added intelligence and efficiency brought to it by the people.

EXPENDITURES.

During the year ending June 30, 1891, the expenditures for public school purposes were:

For buildings, furniture, etc., ..	\$25,851,361
For salaries	95,791,630
For other school expenses.....	25,157,272
Total.....	\$146,800,163

In the year ending June, 1894, the expenditures were:

For buildings, furniture, etc., ..	\$35,000,000
For salaries	120,750,000
For other school expenses.....	28,000,000
Total.....	\$183,750,000

The expenditure per capita of population for the whole country was \$2.70, and for each pupil of the average daily attendance \$20.42. The variation in cost per capita on the average attendance is shown in the statement that for the year 1891

Massachusetts paid per pupil	\$31.00
Illinois " " "	25.50
Montana " " "	48.00
South Carolina " " "	3.00
Georgia " " "	5.00
Texas " " "	11.30

THE WORLD.

If the whole world, with its present population of 1,540,000,000, had systems of public schools like that of the United States, it would have for its 460,000,000 of persons between 5 and 18 years of age, 300,000,000 enrolled in school registers, and 192,000,000 of them in daily attendance for 136 days of the year. There would also be 5,000,000 school houses and 9,000,000 of different persons would serve as teachers a portion of each year, and the annual cost of these schools would be \$4,000,000,000. On the basis of the per capita expenditure for public schools in Massachusetts it would be \$6,000,000,000, and the school property would have a cost value of \$8,530,000,000.

SCHOOLS FOR THE BLIND.

In the United States, in 1891, there were 34 public institutions for the blind, their property being valued at over \$400,000. The income of these institutions for that year was \$1,091,168, and their expenditures \$1,098,837. They cared for a total of 3,237 inmates and employed 417 teachers and attendants.

SCHOOLS FOR THE DEAF AND DUMB.

During 1891 reports were received from 48 public institutions for the deaf and dumb. Their property was valued at over \$12,000,000, and their expenditures for one year were \$1,756,857, and they employed 563 teachers, and had 7,511 inmates; 500 pupils were also taught in public day schools, and there were 13 small private institutions for pupils of this class, caring for about 500 pupils, and employing 70 persons as teachers and attendants.

SCHOOLS FOR THE FEEBLE-MINDED.

There are (1891) eighteen public institutions of this class, with buildings and grounds valued at \$4,000,000. There are also 10 unimportant private schools for such

children, where 400 pupils are cared for. The public institutions provide for 6,000 pupils, employ 132 teachers, 177 attendants, and 400 helpers. The expenditures for these public institutions in 1893 were \$1,411,130.

NORMAL SCHOOLS.

In 1891 there were 31,792 students enrolled in 132 public normal schools, having 1,361 teachers, and there were 10,515 additional students enrolled in 47 private normal schools, which employed 357 teachers. These schools had during the year 6,056 graduates. Many colleges and universities now have professional classes where those who wish to become teachers can prepare themselves for their duties. There are not less than 4,000 students now members of such college classes.

SCHOOLS OF LAW AND OF THEOLOGY.

Fifty-four law schools employ 406 professors and gave instruction during 1894 to about 6,000 students and turned out 2,000 graduates. These schools in 1891 graduated 1,727 young men and taught 5,252. One hundred and forty-three theological schools with 734 professors graduated 1,324 students and taught 7,328 during the year 1891.

SCHOOLS OF MEDICINE, DENTISTRY AND PHARMACY.

During 1891, 230 such schools, colleges and departments reported. They had 3,974 professors and instructors, taught 26,186 students and graduated 7,379. There were also 34 professional schools for nurses with 255 instructors, and 1,613 persons in attendance. Five hundred and twenty-seven nurses graduated from these schools during the year.

COLLEGES OF AGRICULTURE AND MECHANIC ARTS.

These institutions number fifty-seven and were operated during 1892 at a cost of over \$2,000,000. The value of their vast properties is not reported nor is the number of students given.

BUSINESS SCHOOLS.

Two hundred and fifty business schools reported to the Bureau of Education. These schools employed 1,586 instructors, enrolled 58,839 male students and 23,059 females; 14,000 of these students were in the evening business schools.

MANUAL TRAINING SCHOOLS.

In addition to instruction given in many city and state institutions and in those founded by private subscriptions or by bequests, this form of training is now introduced into many institutions and is a growing feature in schools everywhere.

KINDERGARTENS.

There are now not less than 3,500 public and private kindergarten schools in this country instructing 125,000 children. They employ about 10,000 teachers.

HIGH SCHOOLS.

Reports were received in 1891 from 2,773 public high schools which had 8,270 teachers and 211,596 students, 4,180 of these were colored; 12,270 were preparing for science courses in colleges, 12,788 for the classical courses and 25,459 students graduated during the year. In addition to these public high schools there were 1,714 seminaries with 6,231 teachers and 98,400 students, 13,405 of them were preparing to take the classical course in college, and 7,502 for the scientific courses, and 7,108 graduated from these seminaries during the year 1891. The high school feature is an organic part of our system of instruction and could not be dispensed with without very serious injury to the whole. They are worth all they cost as nurseries for teachers alone.

PRIVATE SCHOOLS.

Of the entire 16,000,000 persons enrolled in the schools of the country in 1894, nine and a half per cent. of the elementary grades were in private schools, 40 per cent. of all enrolled in secondary schools were in private institutions, and 70 per cent. of all enrolled in higher instruction were in institutions usually termed private. There is a steady decrease in the number of persons attending secondary private schools, owing to the general establishment of public high schools in cities and villages.

COLLEGES AND UNIVERSITIES.

There are now 430 such institutions of learning, employing, in 1891, 8,472 professors, 1,122 of them being women. The students numbered that year 92,589 males and 28,734 females; 30,000 of these students were in preparatory departments, and 21,000 were studying for the degree of bachelor of arts. There seem to be few persons attending college from the Southern States. Massachusetts has one student in college for every 500 persons of her population, while Arkansas has only one for every 37,000 of hers. 152 colleges for women are reported, having 21,680 students and 1,776 professors. Of the college students, 87,006 were studying Latin, 6,484 Greek, 12,023 French and 33,683 were studying German. Prior to the Franco-Prussian war more students studied French than German, but now there are three taking German to one taking French. The value of college and university property in this country is over \$100,000,000.

A university is a center to which converges the choicest scholarship of a commonwealth. There is nothing like it for attracting able men and affording them the facilities for giving the world the results of their best thought and work, for it is the diffusible quality of the use of knowledge which gives place of learning their great power for good in the world. Human beings are not simply atoms, they are intelligent entities organically related. The university was the first school and it has made all the lower schools possible, reacting to their highest advantage upon all other educational agencies. Logically, the common schools constitute the basis upon which the university rests, and this is quite generally assumed by writers upon educational themes. The reverse of this, however, is true, and the base of the educational pyramid is the university, its apex being the common schools of our country. The endowments of Yale, Harvard, Princeton, Columbia, Johns Hopkins, and Chicago universities were made from surplus accumulations, and all accumulations result from general effort.

DUANE DOTY.

THE WORK OF HERTZ.*

THE untimely end of a young and brilliant career cannot fail to strike a note of sadness and awaken a chord of sympathy in the hearts of his friends and fellow workers. Of men thus cut down in the early prime of their powers there will occur to us here the names of Fresnel, of Carnot, of Clifford, and now of Hertz. His was a strenuous and favored youth; he was surrounded from his birth with all the influences that go to make an accomplished man of science—accomplished both on the experimental and on the mathematical side. The front rank of scientific workers is weaker by his death, which occurred on January 1 of the present year, the thirty-sixth of his life. Yet did he not go till he had effected an achievement which will hand his name down to posterity as the founder of an epoch in experimental physics.

In mathematical and speculative physics others had sown the seed. It was sown by Faraday, it was sown by Thomson and by Stokes, by Weber also, doubtless, and by Helmholtz, but in this particular department it was sown by none more fruitfully and plentifully than by Clerk Maxwell. Of the seed thus sown Hertz reaped the fruits. Through his experimental discovery Germany awoke to the truth of Clerk Maxwell's theory of light, of light and electricity combined, and the able army of workers in that country (not forgetting some in Switzerland and France and Ireland) have done most of the gleaming after Hertz.

This is the work of Hertz which is best known; the work which brought him immediate fame. It is not always that public notice is so well justified. The popular instinct is generous and trustful, and it is apt to be misled. The scientific eminence accorded to a few energetic persons by the popular estimate is more or less unjust to those working in the same lines. In the case of Hertz no such mistake has been made. His name is not over well known, and his work is immensely greater in every way than that of several who have made more noise.

His best known discovery is by no means his only one. I have here a list of eighteen papers† contributed to German periodicals by him, in addition to the papers incorporated in his now well-known book on electric waves. I would like to suggest that it would be an act of tribute, useful to students in this country, if the Physical Society of London saw their way to translate and publish a collection of, at any rate, some of these papers.

PORTRAIT SLIDE.

The portrait which I show is not a specially pleasing one. It is from a photograph taken by Mr. Yule, one of the band of foreign students who flocked to Hertz's laboratory at Bonn. It is excellent as a photograph, though it fails to represent Hertz at his best; perhaps because it was not taken till after the pharyngeal trouble had set in which ultimately carried him off.

In closing these introductory and personal remarks, I should like to say that the enthusiastic admiration for Hertz's spirit and character, felt and expressed by students and workers who came into contact with him, is not easily to be exaggerated. Never was a man more painfully anxious to avoid wounding the susceptibilities of others; and he was accustomed to deprecate the prominence given to him by speakers and writers in this country, lest it might seem to exalt him unduly above other and elder workers among his own sensitive countrymen.

Speaking of the other great workers in physics in Germany, it is not out of place to record the sorrow with which we have heard of the recent death of Dr. August Kundt, professor in the University of Berlin, successor of Von Helmholtz in that capacity.

When I consented to discourse on the work of Hertz, my intention was to repeat some of his actual experiments, and especially to demonstrate his less known discoveries and observations. But the fascination exerted upon me by electric oscillation experiments, when I, too, was independently working at them in the spring of 1888, resumed its hold; and my lecture will accordingly consist of experimental demonstrations of the outcome of Hertz's work, rather than any precise repetition of portions of that work itself.

In case a minority of my audience are in the predicament of not knowing anything about the subject, a five minutes' explanatory prelude may be permitted, though time at present is very far from being "infinitely long."

The simplest way will be for me hastily to summarize our knowledge of the subject before the era of Hertz. Just as a pebble thrown into a pond excites surface ripples, which can heave up and down floating straws

under which they pass, so a struck bell or tuning fork emits energy into the air in the form of what are called sound waves; and this radiant energy is able to set up vibrations in other suitable elastic bodies.

If the body receiving them has its natural or free vibrations violently damped, so that when left to itself it speedily returns to rest, then it can respond feebly to notes of almost any pitch. This is the case with your ears and the tones of my voice. Tones must be exceedingly shrill before they cease to excite the ear at all.

If, on the other hand, the receiving body has a persistent period of vibration, continuing in motion long after it is left to itself, like another tuning fork or bell for instance, then far more facility of response exists, but great accuracy of tuning is necessary if it is to be fully called out; for if the receiver is not thus accurately syntonized with the source, it fails more or less completely to respond.

Conversely, if the source is a persistent vibrator, correct tuning is essential, or it will destroy at one moment motion which it originated the previous moment. Whereas if it is a dead beat or strongly damped exciter, almost anything will respond equally well or equally ill to it.

What I have said of sounding bodies is true of all vibrators in a medium competent to transmit waves. Now a sending telephone or a microphone, when spoken to, emits waves into the ether, and this radiant energy is likewise able to set up vibration in suitable bodies. But we have no delicate means of directly detecting these electrical or ethereal waves, and if they are to produce a perceptible effect at a distance, they must be confined, as by a speaking tube, prevented from spreading, and concentrated on the distant receiver.

This is the function of the telegraph wire; it is to the ether what a speaking tube is to air. A metal wire in air (in function, not in details of analogy) is like a long hollow cavity surrounded by nearly rigid but slightly elastic walls.

SPHERE CHARGED FROM ELEKTROPHORUS.

Furthermore, any conductor electrically charged or discharged with sufficient suddenness must emit electrical waves into the ether, because the charge given to it will not settle down instantly, but will surge to and fro several times first; and these surges or electric oscillations must, according to Maxwell, start waves in the ether, because at the end of each half swing they cause electrostatic, and at the middle of each half swing they cause electromagnetic effects, and the rapid alternation from one of these modes of energy to the other constitutes ethereal waves.* If a wire is handy, they will run along it, and may be felt a long way off. If no wire exists, they will spread out like sound from a bell, or light from a spark, and their intensity will decrease according to the inverse square of the distance.

Maxwell and his followers well knew that there would be such waves; they knew the rate at which they would go, they knew that they would go slower in glass and water than in air, they knew that they would curl round sharp edges, that they would be partly absorbed but mainly reflected by conductors, that if turned back upon themselves they would produce the phenomena of stationary waves, or interference, or nodes and loops; it was known how to calculate the length of such waves, and even how to produce them of any required or predetermined wavelength from 1,000 miles to a foot. Other things were known about them which would take too long to enumerate; any homogeneous insulator would transmit them, would refract or concentrate them if it were of suitable shape, would reflect none of a particular mode of vibration at a certain angle, and so on, and so on.

All this was "known," I say, known with varying degrees of confidence, but by some known with as great confidence as, perhaps even more confidence than, is legitimate before the actuality of experimental verification.

Hertz supplied the verification. He inserted suitable conductors in the path of such waves, conductors adapted for the occurrence in them of induced electric oscillations, and to the surprise of every one, himself doubtless included, he found that the secondary electric surges thus excited were strong enough to display themselves by minute electric sparks.

SYNTONIC LEYDEN JARS.

I shall show this in a form which requires great precision of tuning or syntonism, both emitter and receiver being persistently vibrating things giving some thirty or forty swings before damping has a serious effect. I take two Leyden jars with circuits about a yard in diameter, and situated about two yards apart. I charge and discharge one jar, and observe that the surges set up in the other can cause it to overflow if it is syntonized with the first.†

A closed circuit such as this is a feeble radiator and a feeble absorber, so it is not adapted for action at a distance. In fact, I doubt whether it will visibly act at a range beyond the $\frac{1}{4}\lambda$ at which true radiation of broken off energy occurs. If the coatings of the jar are separated to a greater distance, so that the dielectric is more exposed, it radiates better; because in true radiation the electrostatic and the magnetic energies are equal, whereas in a ring circuit the magnetic energy greatly predominates. By separating the coats of the jar as far as possible we get a typical Hertz oscillator, whose dielectric extends out into the room, and this radiates very powerfully.

ORDINARY SIZE HERTZ VIBRATOR.

In consequence of its radiation of energy its vibrations are rapidly damped, and it only gives some three or four good strong swings. Hence it follows that it has a wide range of excitation, i. e., it can excite sparks in conductors barely at all in tune with it.

The two conditions, conspicuous energy of radiation and persistent vibration electrically produced, are at

present incompatible. Whenever these two conditions coexist, considerable power or activity will of course be necessary in the source of energy. At present they only coexist in the sun and other stars, in the electric arc, and in furnaces.

TWO CIRCULAR VIBRATORS SPARKING IN SYMPATHY.

The receiver Hertz used was chiefly a circular resonator, not a good absorber but a persistent vibrator, well adapted for picking up disturbances of precise and measurable wave length. I find that the circular resonators can act as senders too; here is one exciting quite long sparks in a second one.

Electric Syntonism—that was his discovery, but he did not stop there. He at once proceeded to apply his discovery to the verification of what had already been predicted about the waves, and by laborious and difficult interference experiments he ascertained that the previously calculated length of the waves was thoroughly borne out by fact. These interference experiments in free space are his greatest achievement.

He worked out every detail of the theory splendidly, separately analyzing the electric and the magnetic oscillation—using language not always such as we should use now, but himself growing in theoretic insight through the medium of what would have been to most physicists a confusing maze of troublesome facts, and disentangling all their main relations most harmoniously.

HOLTZ MACHINE, A AND B SPARKS; GLASS AND QUARTZ PANES IN SCREEN.

While Hertz was observing sparks such as these, the primary or exciting spark and the secondary or excited one, he observed as a by-issue that the secondary spark occurred more easily if the light from the primary fell upon its knobs. He examined this new influence of light in many ways, and showed that although spark light and electric brush light were peculiarly effective, any source of light that gave very ultra violet rays produced the same result.*

Wiedemann and Ebert, and a number of experimenters, have repeated and extended this discovery, proving that it is the cathode knob on which illumination takes effect; and Hallwachs made the important observation, which Righi, Stoletov, Branly, and others have extended, that a freshly polished zinc or other oxidizable surface, if charged negatively, is gradually discharged by ultra-violet light.

It is easy to fail in reproducing this experimental result, if the right conditions are not satisfied; but if they are, it is absurdly easy, and the thing might have been observed nearly a century ago.

ZINC DISCHARGING NEGATIVE ELECTRICITY IN LIGHT; GOLD LEAF ELECTROSCOPE; GLASS AND QUARTZ PANES; QUARTZ PRISM.

Take a piece of zinc, clean it with emery paper, connect it to a gold leaf electroscope, and expose it to an arc lamp. If charged positively, nothing appears to happen, the action is very slow, but a negative charge leaks away in a few seconds if the light is bright. Any source of light rich in ultra violet rays will do; the light from a spark is perhaps most powerful of all. A pane of glass cuts off all the action; so does atmospheric air in sufficient thickness (at any rate, town air), hence sunlight is not powerful. A pane of quartz transmits the action almost undiminished, but fluor spar may be more transparent still. Condensing the arc rays with a quartz lens and analyzing them with a quartz prism or reflection grating, we find that the most effective part of the light is high up in the ultra-violet, surprisingly far beyond the limits of the visible spectrum.†

This is rather a digression, but I have taken some pains to show it properly because of the interest betrayed by Lord Kelvin in this matter, and the caution which he felt about accepting the results of the Continental experimenters too hastily.

It is clearly a chemical phenomenon, and I am disposed to express it as a modification of the Volta contact effect; with illumination.

Return now to the Hertz vibrator, or Leyden jar with its coatings well separated, so that we can get into its electric as well as its magnetic field. Here is a great one, giving waves thirty meters long, radiating while it lasts with an activity of a hundred horse power, and making ten million complete electric vibrations per second.

LARGE HERTZ VIBRATOR IN ACTION; ABEL'S FUSE; VACUUM TUBE; STRIKE AN ARC.

Its great radiating power damps it down very rapidly, so that it does not make above two or three swings; but, nevertheless, each time it is excited sparks can be drawn from most of the reasonably elongated conductors in this theater.

A suitably situated gas leak can be ignited by these induced sparks. An Abel's fuse connecting the water pipes with the gas pipes will blow off; vacuum tubes connected to nothing will glow (this fact has been

* The experiment shown in the lecture was on the lines of those described in my book, "Lightning Conductors," pp. 314 and 340; the connections being much as on p. 336, or as depicted in *Proc. Roy. Soc.*, vol. 50, p. 4.

† While preparing for the lecture it occurred to me to try, if possible, during the lecture itself, some new experiments on the effect of light on negatively charged bits of rock and ice, because if the effect is not limited to metals, it must be important in connection with atmospheric electricity. When Mr. Branly coated an aluminum plate with an insulating varnish he found that its charge was able to soak in and out of the varnish during illumination ("Comptes Rendus," vol. 110, p. 586, 1890). Now, the mountain tops of a negatively charged earth are exposed to very ultra-violet rays, and the air is a dielectric in which quiet air-carrying, and sudden downpour of electricity could go on in a manner not very unlike the well-known behavior of water vapor; and this perhaps may be the reason, or one of the reasons, why it is not unusual to experience a thunderstorm after a few fine days. I have now tried these experiments on such geological fragments as were handy, and find that many of them discharge negative electricity under the action of a naked arc, especially from the side of the specimens which was somewhat dusty, but that when wet they discharge much less rapidly, and when positively charged hardly at all. Ice and garden soil discharge negative electrification, too, under ultra-violet illumination, but not so quickly as limestone, mica schist, ferruginous quartz, clay, and some other specimens. Granite barely acts; it seems to insulate too well. The ice and soil were tried in their usual moist condition, but, even when thoroughly dry, soil discharges quite rapidly.

No rock tested was found to discharge as quickly as does a surface of perfectly bright metal such as iron, but many discharged much more quickly than ordinary dull iron, and rather more quickly than when the bright iron surface was thinly oiled or wetted with water.

To-day (June 5) I find that the leaves of a geranium discharge positive electrification five times as quickly as negative, under the action of an arc light, and that glass cuts the effect off, while quartz transmits it.

‡ See "Brit. Assoc. Report," 1894, pp. 562, 519; or *Phil. Mag.*, vol. 19, pp. 397, 398.

* A lecture delivered at the Royal Institution on Friday, June 1, by Prof. Oliver Lodge, F.R.S.—*Nature*.

Hertz's Papers.

1878-79. *Wied. Ann.*, 1880, vol. 10, p. 414. Experiments to Establish an Upper Limit for the Kinetic Energy of Electric Flow.

1880. Inaugural Dissertation (Doctor Thesis) on Induction in Rotating Spheres.

1881. Vol. 13. *Wied. Ann.*, p. 368. On the Distribution of Electricity on the Surface of Moving Conductors.

1883. March. *Schweizerische Zeitschrift*, p. 125. On the Distribution of Pressures in an Elastic Circular Cylinder.

1881 (?) *Crelle*, vol. 92, p. 126. On the Contact of Solid Elastic Bodies.

1882. *Verhandlungen des Vereins der Naturforscher* (Sonderabdruck). On the Contact of Solid Elastic Bodies and on Hardness.

1881. Vol. 14. *Wied. Ann.*, p. 361. Upper Limits for the Kinetic Energy Moving Electricity.

1882. *Wied. Ann.*, vol. 17, p. 177. On the Evaporation of Liquids, especially of Quicksilver, in Air-Free Space, and on the Pressure of Mercury Vapor.

1883. *Wied. Ann.*, vol. 20, p. 270. On the Property of Benzene as an Insulator and as showing Electric Reaction (Eckstättelbilder).

1882. *Verhandlungen des Vereins der Naturforscher in Berlin*, p. 18. On a New Hygrometer.

1883. *Wied. Ann.*, vol. 19, p. 78. On an Apparatus accompanying Electric Discharge.

1883. *Zb.*, vol. 19, p. 792. Experiments on Glow Discharge.

1883. *Zeitschrift für Instrumentenkunde*. Dynamometric Contrivance of Small Resistance and Infinitesimal Self-Induction.

1884. *Met. Zeitschrift*, November, December. Graphic Methods for the Determination of the Adiabatic Changes of Condition of Moist Air.

1884. *Wied. Ann.*, vol. 22, p. 449. On the Equilibrium of Floating Elastic Plates.

1884. *Zb.*, vol. 23. On the Connection between Maxwell's Electrodynamical Fundamental Equations and those of Opposition Electrodynamics.

1885. *Zb.*, vol. 24, p. 114. On the Dimension of a Magnetic Pole in Different Systems of Units.

1887-89. Papers incorporated in his book, "Ausbreitung der Elektrischen Kraft," translated under the title of "Electric Waves."

1902. *Wied. Ann.*, vol. 45, p. 28. On the Passage of Cathode Rays through Thin Metal Sheets.

† *Phil. Mag.*, xxvi., pp. 229, 230, August, 1888; or "Lightning Conductors and Lightning Guards," (Whittaker), pp. 104, 105; also *Proc. Roy. Soc.*, vol. 1, p. 57.

familiar to all who have worked with Hertz waves since 1889; electric leads, if anywhere near each other, as they are in some incandescent lamp holders, may spark across to each other, thus striking an arc and blowing their fuses.

This blowing of fuses by electric radiation frequently happened at Liverpool till the suspensions of the theater lamps were altered.

The striking of an arc by the little reverberating sparks between two carbon points connected with the 100-volt mains I incidentally now demonstrate.

There are some who think that lightning flashes can do none of these secondary things. They are mistaken.

SPECIMENS AND DIAGRAMS.

On the table are specimens of various emitters and receivers such as have been used by different people. The orthodox Hertz radiator of the dumbbell type, and the orthodox Hertz receivers—a circular ring for interference experiments, because it is but little damped; and a straight wire for receiving at a distance, because it is a much better absorber. Beside these are the spheres and ellipsoids (or elliptical plates) which I have mainly used, because they are powerful radiators and absorbers, and because their theory has been worked out by Hertz, Lamb and J. J. Thomson. Also dumb-bells without air gap, and many other shapes, the most recent of mine being the inside of a hollow cylinder with sparks at ends of a diameter; this last being a feeble radiator but a very persistent vibrator,* and therefore well adapted for interference and diffraction experiments. But, indeed, spheres can be made to vibrate longer than usual by putting them into copper hats or inclosures, in which an aperture of varying size can be made to let the waves out.

Many of these senders will do for receivers too, giving off sparks to other insulated bodies or to earth; but besides the Hertz type of receiver, many other detectors of radiation have been employed. Vacuum tubes can be used, either directly or on the trigger principle, as by Zehnder,† the resonator spark precipitating a discharge from some other auxiliary battery or source of energy, and so making a feeble disturbance very visible. Explosives may be used for the same purpose, either in the form of mixed water gases or in the form of an Abel's fuse. Fitzgerald found that a tremendously sensitive galvanometer could indicate that a feeble spark had passed, by reason of the consequent disturbance of electrical equilibrium which settled down again through the galvanometer.‡ This was the method he used in this theater two years ago. Blyth used a one-sided electrometer, and young Bjerkness has greatly developed this method, abolishing the need for a spark, and making the electrometer metrical, integrating, and satisfactory.§ With this detector many measurements have been made at Bonn by Bjerkness, Yule, Barton and others, on waves concentrated and kept from space dissipation by guiding wires.

Mr. Boys has experimented on the mechanical force exerted by electrical surging, and Hertz also made observations of the same kind.

Going back to older methods of detecting electrical radiation, we have, most important of all, a discovery made long before man existed, by a creature that developed a sensitive cavity on its skin; a creature which never so much as had a name to be remembered by (though perhaps we now call it trilobite). Then, in recent times, we recall the photographic plate and the thermopile, with its modification, the radio-micro-meter; also the so-called bolometer, or otherwise known Siemens' pyrometer, applied to astronomy by Langley; applied to the detection of electric waves in wires by Rubens and Ritter and Paulzow and Arons. The thermal junction was applied to the same purpose by D. E. Jones and others.

And, before all these, the late Mr. Gregory, of Cooper's Hill, made his singularly sensitive expansion meter, whereby waves in free space could be detected by the minute rise of temperature they caused in a platinum wire: a kind of early and sensitive form of Carlew voltmeter.

Going back to the physiological method of detecting surging, Hertz tried the frog's leg nerve and muscle preparation which, to the steadier types of electrical stimulus, is so surpassingly sensitive, and to which we owe the discovery of current electricity. But he failed to get any result. Ritter has succeeded; but, in my experience, failure is the normal and proper result. Working with my colleague, Prof. Gotch, at Liverpool, I too have tried the nerve muscle preparation of the frog, and we find that an excessively violent stimulus of a rapidly alternating character, if pure and unaccompanied by secondary actions, produces no effect—no stimulating effect, that is, even though the voltage is so high that sparks are ready to jump between the needles in direct contact with the nerve.

All that such oscillations do, if continued, is to produce a temporary paralysis or fatigue of the nerve, so that it is unable to transmit the nerve impulses evoked by other stimuli, from which paralysis it recovers readily enough in course of time.



Experiment of Gotch and Lodge on the physiological effect of rapid pure electric alternations. Nerve and muscle preparation, with four needles or else non-polarizable electrodes applied to the nerve. C and D are the terminals of a rapidly alternating electric current from a conductor at zero potential, while A and B are the terminals of an ordinary very weak galvanic or induction coil stimulus only just sufficient to make the muscle twitch.

This has been expected from experiments on human beings; such experiments as Tesla's and those of d'Arsonval. But an entire animal is not at all a satisfactory instrument wherewith to attack the question: its nerves are so embedded in conducting tissues that it may easily be doubted whether the alternating type of stimulus ever reaches them at all. By dissecting out a nerve and muscle from a deceased frog, after the historic manner of physiologists, and applying the stimulus direct to the nerve, at the same time as some

other well-known 1-100th of a volt stimulus is applied to another part of the same nerve further from the muscle, it can be shown that rapid electric alternations, if entirely unaccompanied by static charge or by resultant algebraic electric transmission, evoke no excitatory response until they are so violent as to give rise to secondary effects such as heat or mechanical shock. Yet, notwithstanding this inaction, they gradually and slowly exert a paralyzing or obstructive action on the portion of the nerve to which they are applied, so that the nerve impulse excited by the feeble just perceptible 1-100th volt stimulus above is gradually throttled on its way down to the muscle, and remains so throttled for a time varying from a few minutes to an hour after the cessation of the violence.

I had intended to exhibit this effect, which is very marked and definite, but it is impossible to show everything in the time at my disposal.

AIR GAP AND ELECTROSCOPE, CHARGED BY GLASS ROD AND DISCHARGED BY MODERATELY DISTANT SPHERE EXCITED BY COIL.

Among trigger methods of detecting electric radiation, I have spoken of the Zehnder vacuum tubes; another method is one used by Boltzmann.* A pile of several hundred volts is on the verge of charging an electroscope through an air gap just too wide to break down. Very slight electric surging precipitate the discharge across the gap, and the leaves diverge. I show this in a modified and very simple form. On the cap of an electroscope is placed a highly polished knob or rounded end, connected to the sole, and just not touching the cap. Such an electroscope overflows suddenly and completely with any gentle rise of potential.



A THIRTEEN YEAR OLD GIANT.

Bring excited glass near it, the leaves diverge gradually and then suddenly collapse, because the air space snaps; remove the glass, and they redive with negative electricity; the knob above the cap being then charged positively, and to the verge of sparking. In this condition any electrical waves, collected if weak by a foot or so of wire projecting from the cap, will discharge the electroscope by exciting surging in the wire, and so breaking down the air gap. The chief interest about this experiment seems to me the extremely definite dielectric strength of so infinitesimal an air space. Moreover, it is a detector for Hertz waves that might have been used last century; it might have been used by Benjamin Franklin.

For to excite them no coil or anything complicated is necessary; it is sufficient to flick a metal sphere or cylinder with a silk handkerchief, and then discharge it with a well-polished knob. If it is not well polished, the discharge is comparatively gradual, and the vibrations are weak; the more polished are the sides of an air gap, the more sudden is the collapse, and the more vigorous the consequent radiation, especially the radiation of high frequency, the higher harmonics of the disturbance.

For delicate experiments it is sometimes well to repolish the knobs every hour or so. For metrical experiments it is often better to let the knobs get into a less efficient but more permanent state. This is true of all senders or radiators. For the generation of the, so to speak, "infra-red" Hertz waves any knobs will do, but to generate the "ultra-violet" high polish is essential.

(To be continued.)

* *Wied. Ann.*, 40, p. 250.

A BOY GIANT.

OUR engraving, for which we are indebted to the *Illustrirte Zeitung*, will give an excellent idea of the size of a boy who is being exhibited at Castan's Panopticon in Berlin. This boy, Karl Ulrich, was born at Gross-Mohnan, Kreis Schweidnitz, on Sept. 12, 1880. His father is a simple forester of rather small stature, while his mother and her other children are of ordinary size. The boy Karl was normal until his third year, but then he began to grow unnaturally fast. He is now 6 ft. 1 in. tall and weighs 200 lb., and his hands and feet are gigantic. According to Dr. Virchow, he shows no symptoms of disease, all the organs performing their functions perfectly, so that it would seem that when Karl has attained his growth he will be larger than any giant ever known. He is said to be a good scholar, giving his teachers great satisfaction, and although he has been so short a time in the metropolis, he displays considerable humor in his answers to the numerous questions put to him by visitors to the museum.

OUR GREAT DEBT TO SCIENCE.

THERE are many thousands of short sighted people that raise a utilitarian cry against the investigators in pure science. Yet these people use the telephone, the telegraph, the electric light, ride on electric cars, and sigh for further applications of electricity to the needs and uses of everyday life. But they never think of Galvani and his frogs' legs. Take out of the world all that science—studied for the pure love of it—has done, and the habitable globe would be in just the state of uncivilization that Central Africa is to-day. Science

does not create labor, nor the industries flowing from it. On the one hand, science is the progeny of the industrial arts; on the other, of the experiences and perceptions that gradually attach themselves to these arts. Industrial labor is one of the parents, and science is the child; but, as we often see in the commercial world, the son becomes richer than the father, and raises his position. Man is the ward of science, and from his necessities spring the industrial arts; the mole can mine and tunnel under the ground; the tailor bird can sew; the fishing frog can throw out a line and bait that nature gives him; the beaver can plaster his house; the spider can spin and weave; but neither in his hands nor feet has man the tools for such work as he must perform in order to live. How have the arts received their great impulses from science? In the early ages the raw material at hand led to its industrial application; and later on the country possessing the raw material became impressed with the character of its industries. The mound builders of America became coppersmiths, because they found native copper, which they considered a variety of stone, and chipped and hammered it into tools without knowing how to forge it hot. Savages living out of the region of native minerals became workers in stone, flint, horn, bone or shell.

As civilization advanced and commerce became established, the mere possession of raw materials was not the only condition of industry. Possessed of what they considered good weapons, barbarous nations broke through the barriers that shut them from the outside world. While the Thracians were scalping their enemies, and spending much time in tattooing their bodies, their neighbors the Phœnicians, sailing the Mediterranean, as the Tyrians had done before them,

* J. J. Thomson, "Recent Researches," p. 244.

† *Wied. Ann.*, 6, p. 77.

‡ Fitzgerald, *Nature*, vol. 41, p. 396, and vol. 42, p. 172.

§ *Wied. Ann.*, 44, p. 74.

found their way out into the Atlantic, and thence to the British Isles. The natives of these isles, dressed in skins, and with their bodies daubed over with yellow ochre or woad, were living and fighting over mines of tin and other minerals that they knew not of. The Phenicians found these mines, took back tin and other minerals with them, and established metallurgic industries. They were acting under the guidance of an infant science. As intelligence rose in the British Isles, and an initiatory science was developed from industrial pursuits, the people no longer sold their raw mineral material to distant nations, but manufactured it for themselves. So long as the growing intelligence of a nation equals or exceeds that of any neighboring nation, its prosperity is secure. The moment any nation allows the intellectual element of production to fall below that of its neighbors, a mere local advantage no longer insures superiority. Science and commerce having opened paths of rapid intercommunication around the globe, the cost of carrying raw material is lessened; and, given an intellectually inferior nation with raw material, the intellectual superiority of another nation far outbalances the possession of that raw material. Intellect is the great factor in commercial success, whether of individuals or nations. Take the case of the skilled bricklayer and of the hod carrier; the first is using brains in his work, the second is using brute force. When he goes up the ladder with his hod of bricks, he has to carry also his own weight—thus wastefully expending force. Some one notices this, and substitutes for the brute force of the human that of the horse; then the horse is displaced by the mechanical force of a steam engine, which can do the work of fifteen men or of two horses in the same time. Coal converted into heat is doing all the work. The coal mined each year in the United States represents in actual work more than the sum of the force of the total population of the globe, assuming all to be strong men. Thus the substitution of a natural force for human power vastly increases the productive capacity of the human race. Guided by an intellect taught by science, the natural forces can do in a few hours what the unaided labor of many men could not do in a lifetime. It was not prophecy, but a flash of genius, that drew from Stephenson the assertion that it is the sun that drives the locomotive engine, by being liberated from the coal in which it has been stored for ages. But man can neither create forces nor endow anything with properties; all that he can do is to convert and combine them into utilities. The man that does this with knowledge is spared the dismal failures of ignorance, but he that tries to use powers without understanding them is inevitably punished for his rash presumption. It is this presumption that causes the mortality and disease that follow in the wake of civilization. Natural law, like the civil, never admits ignorance as an excuse.

In this century three scientists have revolutionized commerce—Oersted, of Copenhagen, and Faraday and Wheatstone, of London. It was of Faraday that Huxley said, in effect, that any nation would do well to spend \$500,000 in discovering such a man, and an equal amount in educating and setting him to work. Bessemer, studying away at steel, has revolutionized ship building. Dr. Joule's studies in the mechanical equivalent of heat produced the compound engine, by which the necessary amount of coal for carrying a given cargo has been reduced more than forty times; that is, a steamship that in 1850 carried a cargo, at an expenditure of 14,500 lb. of coal to a ton, now does the same work by burning about 350 lb. Joule's studies in heat have made it possible for a cube of coal that will pass through a ring the size of a 25 cent piece to drive one ton of cargo for two miles in one of the most improved steamships. In 1880 the rate on grain from New York to Liverpool was 9½d.; in 1886 it was 1d. a bushel. The reduction was primarily due to the scientist Joule. Every time we strike a match we are indebted to the men that have studied science for the mere love of it. The men that worked away at coal tar "just to see what was in it" made the whole world their debtors by discovering alizarin, the coloring principle of madder. And to these men the world is indebted also for aniline, antipyrine, and more than a hundred other coal tar products. Scientists, wondering what was in crude petroleum, found paraffin and vaseline. Pasteur wondered what caused fermentation; he found out, and brought a new era to wine making. The singing and dancing of a tea kettle attracted the attention of a brain, and we have as a consequence all the applications of steam. The swinging of a chandelier in an Italian cathedral before the eyes of young Galileo was the beginning of a train of thought that resulted in the invention of the pendulum, and through it to the perfecting of the measurement of time; and thus its application and use in navigation, astronomic observations, and in a thousand ways we now pass by unnoted, has been of such practical and unceasing value that the debt to scientific thought, even in this one instance, can never be known. Science, in its study of abstract truth, is ever giving to man new beginnings. While the devil is engaged in finding mischief for idle hands to do, science is eternally at work finding something useful for them to do. Perhaps not eternally, but so long as there is an earth, so long as there is a human race, and so long as there remains unrevealed one secret of nature, there will be the scientist studying for the pure love of investigation, and discovering abstract truths that shall benefit humanity. If the world shall ever be at peace in a brotherhood of mankind, that peace will owe its existence to the student of nature—the scientist. Science is knowledge; art is skill in using it. A principle of science is a rule in art. Art may make mistakes by wrongly applying or by ignoring the truths of science. Railways, ocean steamships, all the uses of steam and electricity, gas, our huge buildings, our manufactories, and all that adds to our material comfort, are due to the practical application of scientific principles.—*Chicago Herald.*

EFFECT OF GREAT COLD ON ANIMALS.

PICTET, the French chemist, finds by subjecting animals and insects to the intense cold obtainable from liquefied atmospheric air, that animals show a wonderful power of resistance to its effects. A dog placed in a copper receiver at a temperature of -60 deg. to -90 deg. Centigrade, showed a rise of bodily temperature

of 0.5 deg. in ten minutes, and after an hour and a half had only lost 1 deg. A little later, however, nature gave up the struggle, the temperature fell rapidly, and the animal died suddenly. Insects resist a temperature of -28 deg. but not -35 deg., while myriapods live down to -50 deg. and snails to -130 deg. Bird's eggs lose their vitality at -2 deg. to -3 deg.; ant's eggs at 0 deg. Infusoria die at -90 deg., while bacteria are still virulent at -213 deg. This last fact is, perhaps, the most significant of all.

HOTHOUSE ON RAILS.

By a system of moving glass houses on wheels, with or without heating apparatus affixed, running on rails,



crops which are to be forced, protected or ripened in succession may be brought under the glass as they stand in the soil or on stages.

CRUEL PLANTS.

WE borrow the somewhat odd title of this article from the Proceedings of the Canadian Institute. By the name of cruel plant, Mr. Arthur designates an Asclepiad, the *Physianthus albens*, whose processes we are going to denounce.

In the first place, we shall give a few details in regard to the family to which this singular plant belongs. The Asclepiadaceae are characterized by a five-parted calyx, a gamopetalous corolla and five stamens connected at the base and surrounding two ovaries, which are surmounted by a five-angled fleshy style, at the summit of which are suspended five pollen masses. They include more than six hundred species, a large number of which are very beautiful climbing plants. In Europe they are represented by *Asclepias vincetoxicum* (the common "fame poison"), with flowers of a beautiful white, found in damp woods in summer.

The *Physianthus* is a climbing plant used for covering arbors. It begins to flower in the month of August toward midsummer, and is no sooner in blossom than the insects, attracted by its perfume, visit it in great numbers (Fig. 1).

The innocent butterflies unsuspectingly thrust their very delicate tongue into the flower with the expectation of obtaining a delicious nectar therefrom, and the imprudent individuals find themselves caught like a mouse in a trap (Fig. 2).

The plant, as we have above stated, possesses a double ovary surrounded by the stamens, which are serrulate, and which, at first soft, harden at the epoch of the maturing of the anthers. Let a butterfly try to reach the nectaries of the flower, and its tongue, slid-

ing into a treacherous groove, becomes irremediably fixed between the pincers, which refuse to let go their hold.

This cruel plant has no excuse for such insect murder. The butterfly that it seizes by its tongue and allows to die of hunger does it no good whatever, for it cannot be said that it is an insectivorous plant, as are, for example, the Venus fly trap, the sun dew or the little butterwort of our meadows.

The visits of insects, however, are not always useless to these plants, whose pollen, not being pulverulent, is not easily disseminated. All insects do not allow themselves to be taken by this trap. Some being more vigorous, are capable of escaping, and, in doing so, carry off some of the pollinia, with which they go to fecun-

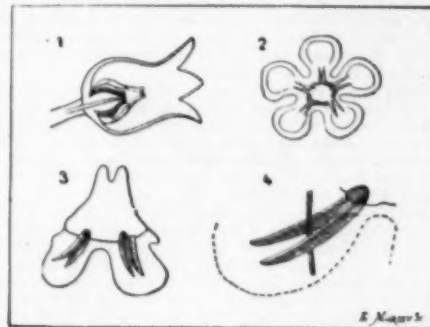


FIG. 2—EXPLANATORY DIAGRAM.

1, section of a flower; 2, plan of a flower; 3, arrangement of the "trap"; 4, figure showing how the tongue of the butterfly is caught.

date other plants and thus bring about a cross fertilization.

Mr. Charles Armstrong remarks, moreover, that the plant acclimated in Canada is a native of Brazil and that it is there exposed to the attacks of more vigorous butterflies, and especially of humming birds, which break the feeble barrier and carry off the pollinia to other flowers.

North America offers us another example of a cruel plant in one of the plumed thistles, *Cnicus discolor*, which has been studied by Mr. Blatchley (*Canadian Entomologist*, December, 1892), and which, on the internal surface of the scales of the involucre, is provided with a large gland that secretes a viscid liquid of which certain insects are very fond. Dr. Asa Gray, in his *Flora*, mentions these glands, whose presence or absence serves for determining the species, but he says nothing about the substance that they secrete.

During the fall of 1891, Mr. Blatchley observed quite a large number of insects assembled upon the scales of the involucre of the thistle, evidently attracted by the secreted liquid. A closer examination permitted him to see that many of these insects were held prisoners, their legs being glued in the viscid liquid. These insects thus died *in situ*, and were so dry that they fell into dust when an effort was made to take hold of them.

Our naturalist one day found eight coleoptera grouped at the base of a thistle head. A single one of them was glued by the legs, but the rest seemed to act as if they had been poisoned by the substance upon which they had fed. They were in such a state of tor-



FIG. 1—FLOWERS OF PHYSIANTHUS VISITED BY BUTTERFLIES.

por that they allowed themselves to be taken without difficulty.

The thistle heads that received the most frequent visits of insects were those whose flowers were withered and whose fruit was beginning to ripen. We cannot, any more than can Mr. Blatchley, give an explanation of the utility of these glands. Hidden thus in the scales of the involucre, they appear to serve, like the glutinous hairs of certain species, only to protect the plant from the attacks of injurious insects. On another hand, the captured insects do not appear to serve as food for the plant. The use of the glands is as yet unexplained.—*La Nature*.

SOME FACTS ABOUT RUBBER.

At a recent meeting of the Merchants' Club, of Boston, Messrs. George A. and A. H. Alden, rubber brokers, thus summarized the leading facts connected with the India rubber industry:

Rubber is a coagulated sap of the *Siphonia elastica* and its kindred genera, a tree, shrub, bush, vine, or weed producing merchantable quantities of rubber in Brazil, the north and west coasts of South America, Central America, Mexico, east and west coasts of Africa and India. Even our common milk weed would produce a very fair rubber. The standard and most reliable rubber in quality, as well as the highest priced—the celebrated "fine Para biscuit"—is produced in Brazil, while the lowest grades and most irregular qualities are the productions of the west coast of Africa; the latter, in fact, are even there deteriorating—due to the carelessness or fraud on the part of the gatherers. We received from a manufacturer some little time since, by express, a hat, boots, and overalls, which, he wrote, he found in a ball of rubber, and that he expected to find the man before he got through with the lot.

The most interesting country in which to study the production of rubber is Brazil, where it has reached its highest standard in that region of heat and moisture, marvelously dense forests, and still more marvelous waterways, the Amazon valley, than which does not exist in the whole world a more fertile region for its size, with its rank growth of vegetation, rubber and dyewood trees, Brazil nuts, artistic woods, fruits, coffee, cocoa, cotton, the Cachassa berry—from which is produced the native rum—tobacco, sugar, and farinha plantations—farinha being the native flour of Brazil. This wonderful river, with its tributaries, drains a territory larger than the whole of the United States, the rise and fall of water between the wet and dry seasons being forty-five feet and upward, so that, during the wet season, the rubber-producing districts (which cover a considerable portion of the valley) are flooded. And here let me say that the so-called rubber plant found in your houses, and admired for its beautiful foliage, is not the tree which produces the rubber of commerce.

Notwithstanding the excessive and continuous heat, the attendant and numerous discomforts always to be found in a tropical country, and the liability to dangerous sickness prevalent to a greater or less degree at different seasons, the valley is inhabited (very sparsely, it is true) by an industrious and hard-working people, as shown by the large and ever increasing exports from Para, which is the principal shipping and receiving port for the valley, situated some sixty miles from the mouth of the Amazon, on one of the many arms of the delta—a city of about 40,000 inhabitants, composed of Brazilians, Portuguese, negroes, and half breeds, with a few American, English, German, and French, who are located there to buy and ship the produce as it arrives.

The rubber is only gathered on the Upper Amazon during the dry season, when the heavy daily rains of the wet season have ceased and the river has contracted itself within its banks. The flooded country gradually becomes less and less marshy, and enables the laborers to penetrate the forests fringing the watercourses to tap the trees. Without experience it is difficult to form an adequate idea of the almost impenetrable vegetable growth on these annually flooded bottom lands, under the influence of an equatorial sun.

At the beginning of a season, say the latter part of May or the early part of June, the emigration of laborers to work on rubber estates is very marked, the steamers from the south (mostly from the province of Ceara) going up the Amazon loaded with rubber gatherers, many of whom return again in the autumn when the rainy season commences. Those who remain live a most indolent life in lightly-built bamboo huts, perched on piling to elevate them above the rising waters.

On the lower Amazon, among the islands, rubber is collected and brought to market every month in the year; but the rubber from the upper river gathered during the dry season only reaches market in the wet season, for the double reason of the necessity for high water to enable the river steamers to reach the higher branches of the river and the enormous distances required to be sailed over by these steamers, whose trips into Peru and the head waters and back cover a greater distance than from here to Liverpool and back, and consume a greater time. Between Para and the Andes Mountains there are 30,000 to 40,000 miles of navigable water of the Amazon and its tributaries.

The rubber from this valley was formerly brought to market in the shape of bottles and shoes, made by the natives over clay moulds, which were then broken and taken out. This method was continued until about 1848 or 1849, when a wooden mould, something after the shape of a paddle, was adopted by the gatherers, and is exclusively used to-day.

Grants of seringueos, or rubber lands, are made by the provincial governments upon application of discoverers or explorers of the same, on the condition of their occupying and working the trees, which are in turn mortgaged to the Para or Manaus merchants as security for the advancement of supplies to the gatherers against rubber to be delivered throughout the crop. Nearly all the available lands are thus taken up, although not all thus pre-empted are worked. These seringueos exist not only on the river margins, but in the interior as well—always, however, in low districts of a swampy nature, near or around lakes or ponds; and from these inland lakes small streams drain into

the river, down which the rubber is floated to the forwarding points for shipment to Para.

Some of the seringueos are very extensive, and many men are employed—divided into gangs—some to keep the paths open from tree to tree by constant chopping and cutting of the wild and luxuriant vegetable growth which would otherwise choke up the paths and render them impassable in a short time. Another gang gathers the milk or sap of the tree, by cutting into the bark in a V-shape, and sticking to the tree at the point of the V a small clay cup or saucer of about two gills capacity, into which the white, milky sap slowly trickles. It is then collected, brought into camp and distributed in large basins among the makers, each of whom has a smouldering fire of nuts covered by a portable clay chimney a foot or so high, from which issues a dense, black smoke. The operation is then a very simple one. The maker covers his paddle with a thin layer of sap, which naturally adheres to it, holds it in the smoke for a moment, at once coagulating it. He then adds another layer, by dipping, and again holds his paddle in the smoke. This operation he repeats again and again, until the merchantable "fine Para biscuit" is produced. The paddle is cut out and the operation repeated.

The biscuit, when finished and cut from the paddle, contains 50 per cent. water, which must be wholly evaporated before it is ready to be put into goods. This loss is divided between the different parties who handle it. The greatest loss is between the camp and Para, where every biscuit is cut for grading of quality. The sweepings of the camp, drippings of the trees, and cleanings from the basins, etc., are more carelessly rolled together into scrappy balls, which are termed negro heads. In Ecuador the sap is floated on to water and mixed with ashes and other foreign stuff to hasten its coagulation, not to mention that it increases its weight.

In Nicaragua, the sap is drawn into tin dishes and is coagulated by mixing with the bruised leaves of a plant which flourishes in that vicinity.

The natives in Africa have a method of gathering by smearing the sap on their naked bodies, coming into camp veritable living rubber men.

The product of rubber of the Amazon valley has more than doubled in the last ten years. The crop ending the summer of 1878 was 7,598 tons, while last year's crop was 15,725 tons. The total consumption of all grades of rubber in the United States last year was 30,000,000 pounds, the value of which was about \$15,000,000.

The Brazilian governments—imperial and provincial—collect an export duty of 22 per cent. on the market value, at the time of shipment, which amounted to about \$3,000,000 last crop.

In the manufacture of rubber goods more than 30,000,000 pounds of metallic oxides and carbonates are used. In addition, large quantities of earthy materials are used, principally to make weight. Cotton and woolen cloths are consumed to the extent of 20,000,000 pounds. Devulcanized or reclaimed rubber amounting to 25,000,000 pounds is also used. This includes almost all the cast-off rubbers, for these old goods eventually find their way back to the mills to be ground up and made into shoes again. This old rubber is worth from 8 cents to 30 cents per pound, according to quality. Without this old stock to draw upon, rubber goods would be a great deal more expensive to the consumer. The capital invested in rubber mills in the United States exceeds \$25,000,000, employing a large number of people, men, women, and girls. The value of rubber thread, toys, etc., made amounts to \$5,000,000; clothing, \$5,000,000; mechanical goods, \$15,000,000; and boots and shoes, \$25,000,000. The number of boots and shoes made daily for nine months in the year will foot up to 150,000 pairs.

THE ANCIENT MONUMENTS AND PALATIAL ARCHITECTURE OF MEXICO AND CENTRAL AMERICA.

THE following is from an interesting paper by Rev. Stephen D. Peet, in the May number of the *American Antiquarian*:

In taking the testimony of the monuments, we shall consult those authors who have visited them, and made a study of them, among whom Mr. J. L. Stephens is regarded as chief. This gentleman, in 1840, started with his companion, Mr. Catherwood, from New York for Nicaragua. The two were fortunate enough to strike upon the very localities where the chief cities of the ancient Mayas were situated, some of which had been seen by the Spaniards, but the majority of them were totally unknown to the conquerors. They were surprised at the extent and magnificence of the ruins, but were able to visit many of them, and take sketches of the chief buildings and statues and works of art, and to write out descriptions of the same. The ruins were scattered over a wide region of country, some of them in Honduras (Quirigua, Copan), others in Guatemala (Quiche, Quezaltenango), others in Chiapas (Ocosingo, Palenque), others in Yucatan (Uxmal, Chichen-Itza, Merida, Kabah), all of them bearing the marks of ancient Maya civilization. The publication of their work made a great sensation, and was for the science of archaeology nearly as important an event as the discovery of America was for history. A few explorers had, to be sure, visited the region before,* and still others followed; but the work of Stephens is the most valuable of all. Bancroft says, "The accuracy of his survey cannot be called in question." It was with great difficulty that the overhanging forest trees were cleared away, and the lines were run out which secured the platting of the various ruins and the location of the pyramids, palaces, temples and altars, with relation to one another; but it was owing to these measurements that we learn the length, breadth and height of the various pyramids, the size of the shrines upon them; also the height and breadth of the terraces which formed the platforms to the palaces; the size and location of the different rooms in the palaces, their courts and corridors; also the length of the walls surrounding the palaces; the size of the carved

pillars and gigantic faces and sculptured altars which surrounded the pyramids; also the length and breadth of the tablets confined within the shrines or adoratorios. From these we determine the character of the different buildings, and decide which were devoted to purposes of royalty, which were used for religious objects, and even decide as to the use of the different apartments in each of the buildings. The description of Mr. Stephens reveals to us the beauty of the sculpture and the magnificence of the architecture, as well as the grandeur of the ruins. It is, however, owing to the skillful hand of the artist Catherwood that we are furnished with drawings which bring out in detail all the ornaments which were wrought into the facades of the palaces and of the shrines, and even the sculptured figures or portraits embodied in the statues, and are able to study the symbols and hieroglyphics which appear on them in great numbers. The plates in the book are among the chief sources of authority and information on these subjects and well repay examination. These gentlemen found the most interesting objects at Copan. The ruins here were two miles in extent, and seemed to represent a palace with courtyards, and buildings around the courts, situated upon terraced pyramids, with wide steps leading to the buildings, colossal heads upon the sides of the pyramids, and what is most interesting of all, nineteen statues covered with the most elaborate sculptured ornaments, and containing the figures which may have been the portraits of the kings and queens who occupied the palace. There were altars covered with most elaborate symbols near seven of these statues, conveying the idea that sacrifices may have been offered to the kings. The sculpture upon some of the statues filled the travelers with astonishment, for it was very beautiful and elaborate, as can be seen from an examination of the plates and the cuts. Quirigua, about twenty miles distant, presented also a collection of statues of the same general character as those at Copan, but somewhat larger; they were carved pillars, with figures on the front and back, and hieroglyphics on the sides, some of them twenty-three feet above the ground, with a base projecting fifteen or sixteen feet. At Quiche there was an extensive fortress surrounded with ravines, a palace and a place of sacrifice, but no statues were visible. The place of sacrifice was an isolated pyramid, broken and ruined, but was supposed to be an altar erected for the sacrifice of human victims.

At Palenque were the most extensive ruins, most of the buildings facing the cardinal points; there were palaces with corridors and courts and sculptured groups in the courts, also a shrine, with a sculptured tablet in the shrine. Near by were various temples or shrines which contained the tablets and were named after the tablets; the temple of the cross, the temple of the sun, the temple of the three tablets. These shrines or adoratorios presented on their facades many remarkable figures in bass-relief, some of which evidently represented divinities, or the priests which presided. At Ocosingo, in Chiapas, was a terraced hill or elevation, and on the summit a pyramid which supported a stone building eleven by eighteen feet. Over the doorway, on the outside, was the stucco ornament which resembled the winged globe of the Egyptian temples. At Uxmal was the most interesting group of ruins. Here was the building known as the governor's house, or Casa de la Gobernador; a pyramid rising in three terraces, the sides measuring five hundred and forty-five feet and reaching the height of forty feet. It supports a building three hundred and twenty-two feet long, thirty-nine feet wide and twenty-six feet high, with two rows of corridors, and heavy cornices, and above the cornice, beautiful sculpture. Here was the two-headed idol and the pectol, also the Casa de Palomas, also the Casa de la Vieja or old woman's house, so named from a statue lying near its front; also the Casa de Monjas, or Nunnery, with its four interior facades fronting the court, with the cornice, which covered over twenty-four thousand square feet for the four buildings, filled with elegant and elaborate sculpture. This building was remarkable for its symbolism. Over the doorways of the southern court were the ornaments which resembled a small hut or shrine, with a statue seated within the door, and above the shrine was the ornament resembling the human face and eye; lattice work and ranges of pillars on either side. On the eastern court were horizontal bars terminating in serpents' heads, on which hung a gigantic mask or human face with peculiar head dress, ear pendants and protruding tongue. On the western court was the serpent temple, a building whose facade was covered with lattice work, ornaments in the shape of the Greek fret and two massive serpents in relief, which formed the panels, their bodies interlacing and surrounding the entire front, the tail and head at either end of the building with a human face within the jaws.

At Chichen-Itza were the numerous buildings which were called the "castle," the approach to which was guarded by the serpent balustrade, also the "gymnasium" with its stone rings in the shape of serpents; also the buildings in which were the figures sculptured in bass-relief, representing the human form with plumed head dress and bunches of bows and arrows; the building called the "red house," called by Charnay the "prison;" and the circular building called the "caracol" or winding staircase, by Norman the "dome," which contained the stairways with balustrade formed of two intertwined serpents. The castle was interesting because it contained a carved door jamb representing a prince with crown and peculiar head dress; a sculptured lintel with a figure engaged in mysterious incantation; also the shrine in which were square pillars and carved zapote beams and doorways upon the four sides, and the serpent balustrade.

These discoveries of Mr. J. L. Stephens were for a long time relied upon as about the only authority; but M. Desiré Charnay has made two visits to the same localities, one in 1858 and the other in 1878, and has brought out some new points in connection with the ruins. He visited Mexico and examined the ruins at Tulan, and found the same general arrangement of

* Wadlock, a French artist, in 1835; Norman, from New Orleans, in 1843; Charnay, the French author, in 1858 and again in 1878; Frederichs in 1841; Capt. Del Rio, 1736; Dupuis, 1803. Col. Galindo, governor of the province of Yucatan, explored Copan in 1853, and published an account in the bulletin of the Société de Géographie, of Paris, and in *American Antiquarian*, Soc. Trans. Vol. II., p. 545.

* This winged figure resembled that on the facade at Palenque.

† Charnay says that "pectols were placed in the center of the plaza of the palace at Chichen-Itza, and slaves were fastened to it to be punished."

apartments as Stephens had seen at Uxmal and Palenque. He also passed over the mountains and reached the cities of the Mayas, and made the discovery of another city, to which he has given the name of Lorillard. He took photographs of the various buildings which were drawn by the artist Catherwood, and has furnished some interesting descriptions of them all. The result of his efforts confirms the impressions which were received from the engravings and descriptions in the work of Stephens. At Tulan he found a temple consisting of pillars in the shape of serpents, the heads of which formed the base and the tails the capital. Similar pillars supported the facade of the building El Castillo, at Chichen-Itza, having serpents' heads at the base and feather ornaments at the sides, thus showing that the same symbols were employed by the two races. He speaks of the analogies between the sculptures of the two regions. He calls it all Toltec. His photographs of the tablet of cross No. 3 at Palenque bring out the fact that there were hidden away among the foliage which forms the arms of the cross certain masks which suggest that there was a personal element as well as the "nature powers" embodied in this shrine. The face near the top of the cross, a necklace and medallion below the face, remind us of the adornments of the kings and chiefs. The protruding tongue in the tablet of the temple of the sun, Casa No. 1, reminds one of the protruding tongue in the calendar stone of Mexico. These photographs bring out more than ever the magnificence in the ornaments and decorations on the facades of the different palaces, those on the palace at Kabah being very beautiful.* The facade of the Dwarf's House or Nunnery is very imposing. The panoramic view of all the buildings at Uxmal is especially interesting, as it enables us to form a correct estimate of the character of the architecture of the Mayas. In the city called Lorillard there was a magnificent building called the "first temple," another called the "second temple," another called the "palace." In these are sculptured lintels made from wood and stone which represent persons in royal attire; one of them represents a sacrifice to Cuculkan or a penitential scene.

The descriptions and engravings furnished by these two travelers enable us to recognize the differences between the different classes of monuments, for we find in all of the cities altars devoted to sacrifice, pyramids and palaces which were devoted to royalty, shrines devoted to worship, all having ornaments and symbols which were correlated to the design or the purpose of the buildings themselves. This is especially apparent in the shrines which were devoted to specific divinities, for the sculptured figures on some of the temples, whether outside upon the facades or upon the piers and doorways or upon the tablets in the inner chamber, are all significant of the worship of one divinity, the one to whom the temple was devoted. Such shrines are to be distinguished from the palaces. The palaces were full of rooms, which were occupied by the royal family, and between the rooms were courts and corridors, and apartments of state, and all the conveniences which became the home of royalty. There were occasionally shrines in the palace, in private apartments, in which altars and tablets were erected. Surrounding the palaces were large inclosures, some of which were used for gardens. In the gardens, at the foot of the pyramids, there were statues decorated with the adornments of royalty, and on the sides of the pyramids gigantic heads, some of them fifteen feet high, as high as the columns themselves. These, however, only confirm the impression already formed—namely, that the statues within the palaces were the portraits of deified kings, that the figures on the tablets in the shrines represented the nature divinities, and if there are any "culture heroes" to be recognized, they are to be found upon the isolated shrines or upon the pyramids which contained statues upon their summits.

It may be that there were capitals, in which kings had their seats of empire, but there were also sacred cities devoted to particular gods. Charnay thinks that Palenque was not a royal palace, but a priestly habitation, a magnificent convent occupied by the clergy, and, like Teotihuacan, Izamal and Cozumel, a city resorted to as a place of pilgrimage. He thinks that there were capitals in which were kingly mansions, and the history of the people can be found among the reliefs. Tezeuco of New Mexico may have been such a capital among the Nahuas; Copan, Chichen-Itza, Quirigua, Uxmal and Kabah may have been the capitals of the Mayas. Whether there were cities or shrines which were sacred to the culture heroes of the Mayas, as Cholula was among the Toltecs, remains a question. The national divinities, such as Quetzalcoatl, Huitzilopochtli, ruled over particular cities among the Nahuas, and it may be there were national divinities among the Mayas. The palace at Tezeuco was a collection of buildings composed of royal residences, public offices, courts of law. It extends from east to west 1,234 yards, and from north to south 987 yards. There were in it two large plazas or courts, one of which served as a public market. A palace devoted to Quetzalcoatl had halls facing the four cardinal points. The hall of gold faced to the east, the hall of emeralds faced to the south, the hall of silver, decorated with sea shells, faced to the north, and the hall decorated with feather work faced to the west. This was in the northern province, but the ruins which have been found in the southern provinces of Yucatan and Guatemala are more magnificent than those of Mexico. This forces upon us the conviction that there were three classes of beings that were worshipped—nature divinities, culture heroes and deified kings.

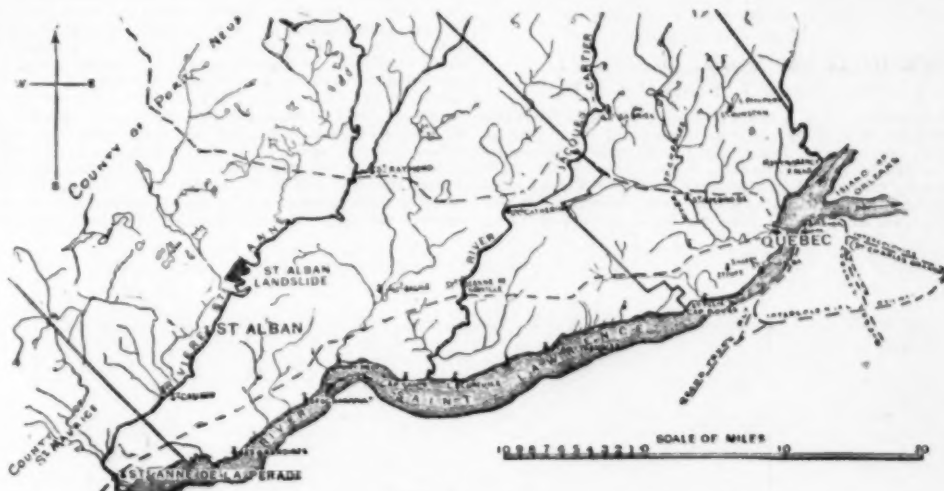
The task is to distinguish the divinities from kings. The clew is furnished to us by the study of the symbols, especially when taken along with the character of the pyramids, and the buildings on the pyramids. We have spoken of the correlation. Let us consider the resemblances and contrasts. There are at Copan symbols on the statues or sculptured columns which resemble those on the door-posts and facades, as the

same or similar head-dresses and personal ornaments are repeated. At Palenque there are symbols on the tablets in the shrines which resembled those found on the piers and facades, but as a general thing the ornaments and symbols on the shrines differed from those on the tablets, and the symbols on the palaces differed decidedly from those on the altars; those on the altars differed from those on the friezes and cornices of the facades. This shows that the symbolism of the Mayas was correlated to the design, and that the distinction between the royal personages and the nature divinities prevailed in all the cities.

THE ST. ALBAN LANDSLIDE, NEAR QUEBEC.

On the 27th of April last one of the most extensive landslides ever recorded occurred on the Ste. Anne River, near the village of St. Alban, 40 miles west of the city of Quebec. For 30 miles north of the St.

the river was then dammed back for $3\frac{1}{2}$ miles in length by $\frac{1}{4}$ of a mile in width. The surface of the water was raised about 100 feet until it gathered sufficient force to burst the barrier, when it swept down southward, carrying with it both clay and sand; together with the forest trees, which were prostrated before the torrent as easily as a field of grain. This stream, No. 1, crossed the old river bed and ran straight to the old channel at Sand Point. While this was being done all the land east of channel No. 1 was sliding into the old river bed and filling it up. Banks were falling in all directions with a sound resembling the roar of artillery, one crash succeeding another. Forest trees rocked and plunged headlong into the flood. The water was thrown into the air in clouds of spray. The shocks were distinctly felt for 7 miles and the sound was heard at a distance of 10 miles. The waterfall, 105 feet high, at the Gorrie mill, was buried 50 feet deep, and the pulp mill, two houses and a barn at the foot of the falls, were buried 80 feet deep, by



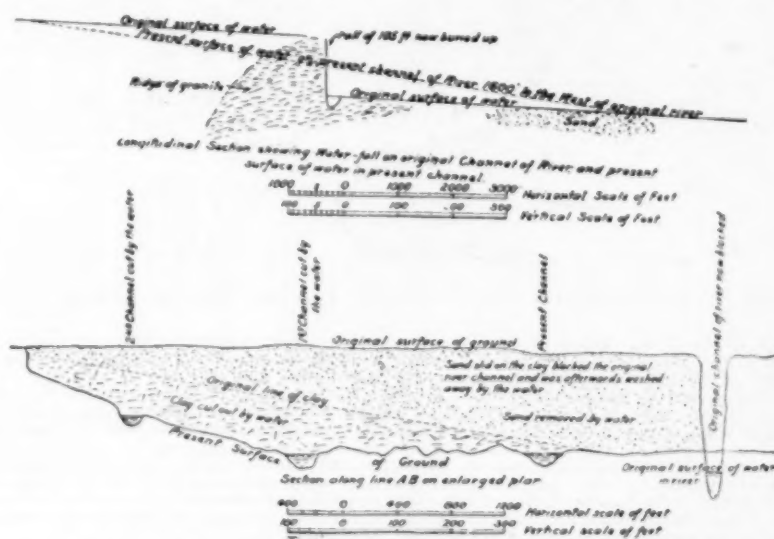
GENERAL LOCATION OF THE ST. ALBAN LANDSLIDE.

Lawrence River the land rises gently to the base of the Laurentian Mountains. The surface soil is sandy, underlain by clay in horizontal layers. These layers separate readily and dissolve easily in water. At the St. Lawrence the clay is quite soft, but becomes harder further inland. Near the base of the mountains, the clay again becomes soft and is overlain by sand of different depths. The whole plain between the St. Lawrence and the mountains appears to have been at one time a sea or lake bottom.

Referring to the plan, it will be seen that at the south end of the landslide the sand bank is 175 feet high and rests upon clay. To the north and west, for $3\frac{1}{2}$ miles, the clay rises gradually to within 10 feet of the surface, where it meets the sand. This 10 feet depth of sand is maintained along the north end of the break, and south as far as the "horseback hill." Between this hill and the old channel, and south along the left bank of the river to the south end of the break, the sand bank was 200 to 250 feet high, resting

the "horseback hill," which had moved 450 feet, clay sliding on clay. The area of this hill is about 50 square acres, and it was moved bodily without disturbing any of the trees which grew upon it.

Channel No. 2 now branched off from channel No. 1, and ran southeast, curving to the northeast and joining channel No. 1 where it crossed the old river bed. As the land between these two channels suddenly slid to the east and sank into the roaring flood, a terrific scene of desolation was presented. The Gauthier house and its four occupants were engulfed. The water rising against the banks in the south curve of channel No. 2, saturated the sand bank, southwest, for a half a mile; the surface of the clay then being lubricated, the whole half mile of sand bank, 175 feet high, began moving southeast, carrying with it houses, barns, cattle and people. The latter, repeating their prayers in the full belief that the end of all things had come, fled for their lives, dragging their children in the darkness through water waist deep.



PROFILES OF CHANGES MADE BY THE ST. ALBAN FLOOD.

on clay about level with the water, so that the surface of the clay was inclined toward the river, at and south of the line A-B on plan. In the old river bed, east of the "horseback," the water fell over a granite ridge 105 feet high. At the foot of the fall stood the Gorrie mill. The desolated area is about $3\frac{1}{2}$ miles long by 1 mile wide, and the depression is, on an average, about 100 feet below the general surface.

The greater part of the catastrophe happened in the night, so that it is impossible to give a strictly correct account of it. The melting on the mountains of the excessive snowfall of the winter caused an unusual rise of water in the river. The northern part of the land was forest, and it is supposed that early in the evening the shaded portion, shown at the top of the plan, first slid into the river and completely blocked the channel. This was probably clay sliding on clay, along a plane where water had percolated either from springs, from the brooks which flowed into the river near this point, or from the river itself. The water of

In some places the earth was moving faster than the people could run in the opposite direction, so that more than once they were drawn back into deeper water and almost lost. All escaped, however, except two women and nine children, who were cut off by the water and isolated on a small island where they spent the night. They succeeded in kindling a fire, around which they huddled, expecting every moment to be their last on earth, until the morning dawned, when they were rescued and taken off in a boat.

The water was converted into a mass of quicksand on which large trees were borne upright. Heaps of dry sand fell on this semi-fluid mass of sand and clay with loud noise, and the moving mass of mud and forest was carried away toward the sea, destroying every highway bridge in its path. A house, several acres of land and some ornamental trees were carried bodily three-quarters of a mile before any injury was done to them.

Lastly, channel No. 3 was opened, and now runs 70

* At Ake was a palace with a courtyard and a plot in the center of the plaza, as at Uxmal; also a small oval pyramid, a tennis court, a ruined palace and a great gallery of columns. At Itzamal a massive face at the base of a pyramid, at Chichen-Itza a perpendicular pyramid, the base occupied by eight large idols, a fortress or pyramid, two serpents forming a winding staircase.

feet vertically above the original river bed south of the "horst" hill.

At the bottom of the sunken area lie fragments of the original surface thrown together in the wildest confusion. The water is still charged with as large a quantity of clay and sand as it can hold in suspension. It is quite probable that future floods will cause the river to traverse this sunken area from side to side, and likely cut away the sand point now projecting out at the southeast corner. Fifteen days after the landslide, a dam of driftwood was formed almost across the river near the village of Ste. Anne de la Perade, causing the current to undermine the concave bank, with the result that a piece of land 180 feet wide and 1,000 feet long fell into the stream, carrying with it five houses and endangering the whole village.

The Canadian Pacific Railway bridge, over the Ste. Anne River—a fine iron structure on substantial stone piers—was for several days in great danger. The district superintendent and resident engineer were on the spot with a steam pile driver and 100 cars of material ready for any emergency. Fortunately the bridge sustained no serious damage.—*Railroad Gazette*.

WHAT IS A CLOUD BURST?

By CHARLES L. HOGEBOM, M.D.

A SUDDEN fall of a great quantity of water from the sky upon a limited area, as if emptied from a huge vessel, producing a disastrous inundation, is an occurrence difficult to compare or reconcile with the more ordinary natural phenomena around us. To say that a cloud burst is electrical and pluvial affords no explanation, for an ordinary thunder cloud is both of these,

sequent phenomenon far exceeds that to which the mere name of rainfall can be given; it becomes an enormously voluminous pour of water, which constitutes a cloud burst, and is accompanied by a loud roll of thunder or a series of thunder-claps.

Why are these phenomena more frequent than formerly? The same causes which have increased the number and fury of tornadoes and of floods have also increased the number and volume of cloud bursts. The destruction of timber of giant size and having powerful climatic functions, by which the clouds are relieved of their excess of electricity, as well as the potential of the sky itself, is the prime cause of cloud bursts. This is illustrated by the recent catastrophes in the region of Puget Sound. Thousands of square miles of heavy timber of immense height have been destroyed there, in many instances cut down, piled together, and burned up. The forests are vanishing rapidly from British Columbia and from Canada. The land-slides and attendant calamities which have lately been experienced in the Province of Quebec are the natural outcome of the extensive forest devastation in that region. Its continued progress in other parts of British America will involve serious consequences to that country. Franklin understood the subject of cloud bursts, as he did much of the phenomena of atmospheric electricity, but, of course, there is more involved in the science than in his day, and more investigation will be required to solve many problems. Writing to Collinson in 1749, he says: "For if an electrified cloud coming from the sea meets in the air a cloud coming from the land, and, therefore, not electrified, the first will flash its fire into the latter, and thereby both clouds shall be made suddenly to deposit water." It may be remarked here also that Franklin

extensively deforested, the clouds are more highly charged with moisture and electricity than formerly, and the southwest quarter of a cyclone is a still greater theater than ever for the destructive effects of the tornado, and also the place for the formation of cloud bursts and other violent storms.

There is more moisture in the arid regions of the far West than formerly, and various causes have been assigned, but the principal one is that the electrical potential of the air from the Pacific remains higher than before extensive deforestation in that region. In this respect the result is beneficial; but the increased storms and floods in the Mississippi Valley, arising from deforestation of the eastern half of the Union, enormously overbalance the good results which are claimed to have followed any other changes. A little more deliberate development of our country should have been accompanied by a greater amount of wisdom than the American people have displayed.—*The Outlook*.

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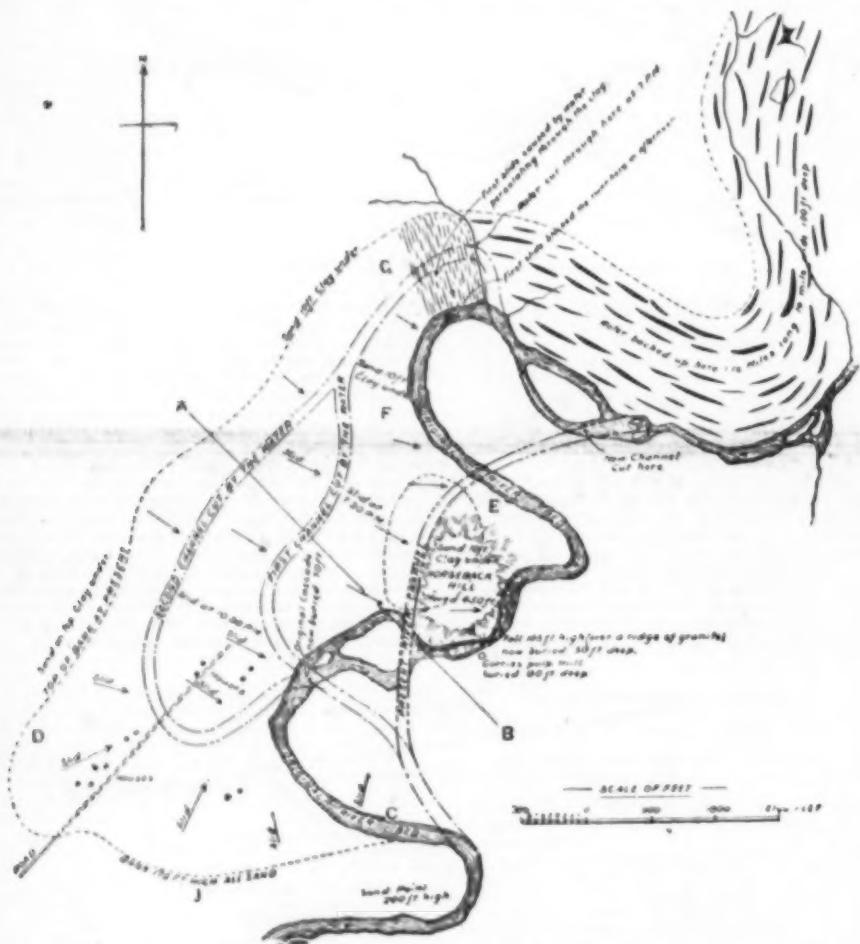
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PLAN OF THE VARIOUS CHANNELS CUT DURING THE ST. ALBAN FLOOD.

as well as a tornado cloud. But how can it happen that so great a quantity of water can fall on so small an area? This is the difficult question to answer, because this vast quantity of water could not, for many moments, have been held in one space in the sky; it could not have reached beyond a certain height, and of course it had a horizontal limit. The water must have come rapidly from adjacent cloud spaces. When a thunder cloud explodes, there is a temporary increase of rainfall, as if the water had been shaken from the cloud. This is something of an approach to a cloud burst, and affords a partial explanation of it, but does not satisfy our desire to know whence so extraordinary a quantity of water suddenly came. A discharge of electricity from any volume of vapor must result, in some degree, in the condensation of that vapor, for the effect of high electrical potential in a cloud is to cause all the particles of vapor or moisture to repel each other until the repulsion reaches equilibrium. Now, in some particular part of a general storm—that part where electricity begins to manifest itself—if there happens to be an extensive group of thunder clouds, saturated with moisture, or nearly so, and extending over a large area, and of sufficiently equal electrical potential or degree of electrical charge to keep them from uniting until the equilibrium is somewhere broken by a discharge taking place to some gear object, as a mountain peak or crag, or giant tree, we have the conditions for the formation of a cloud burst. When such equilibrium is destroyed at any point from any cause, electrical attraction at once takes place between the cloud masses, and they rush in from all quarters to supply the deficiency, in this respect resembling observed cases of tornado formation; and all is accomplished so rapidly that the con-

was the first to observe that northeast storms move from the southwest, in a letter written to Jared Eliot, dated June 10, 1747.

But cloud bursts are greater now than in Franklin's day, for their causes have been greatly increased. Tall trees, especially pines, have a much greater power than bare mountain peaks for drawing electricity from the sky, for the same reason that pointed wires placed near the prime conductor of an electrical machine have the power of collecting the electric fluid generated by the friction between the rubber cushion and glass plate or cylinder.

Electricity is as much concerned in cloud formation as in the production of cloud bursts. Any observer can, on a hazy day, or when there are light clouds floating in the sky, witness the formation of fine striated clouds. It would be impossible to form any other explanation than that these striae were the effect, principally, of electrical repulsion acting upon either aerial vapor or light visible cloud. This is undoubtedly the cause of changes of form in "mackerel sky" in "cheek-board" formation. Electricity is always present in the sky, as it is everywhere else, in masses, molecules, and atoms, and is constantly changing in relative quantity. The clouds which come fresh from the ocean have the highest potential. Those which form or which come over the land, especially over timbered regions, have parted with much electricity, and therefore have lower potential, as was so accurately observed and clearly explained by Franklin, although using somewhat different terms. It is thus seen that clouds having the highest electrical charge have also the highest moisture capacity, just as a thunder cloud has, and, in a still higher degree, a tornado cloud. Now, since the Atlantic and Middle States have been

